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Predetermination as an Influence on Yield in Wheat Plants.

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Summary.

Experiments with wheat have been conducted over a period of two years to determine whether predetermination is important in causing variation in the yield and yield attributes of a pure line. The characteristics examined included time of blooming of the flower, size of seed and embryo scar, rate of germination, and amount of early growth in 16 days. The following conclusions have been drawn:—

1. Predetermination is important in causing variation in the progeny of a pure line.
2. In wheat, the factors associated with seed weight and early growth (sixteen days after sowing) cause variation in the individual yields of the progeny.
3. There is some association between seed weight and early growth, but apart from this, each (the factors affecting each) has a separate influence on yield. The variance in yield correlated with these characteristics amounts to 24 per cent., $R = 0.49$.
4. The effect of the factors is chiefly upon ear number, but also upon grain number.
5. This shows quite clearly that, even if extreme measures are adopted to provide uniform conditions for the developing plants, there will still be a considerable amount of plant to plant variation due to predetermining influences.

With a view to determining the various factors and their value on yield in wheat plants for genetic purposes, the characteristics of individual plants must be examined. As soon as this is commenced, the tremendous variation in the final yield and the yield attributes between individual plants becomes most evident, even in pure lines. Such variation is usually attributed to the effect of environment on the organism. It is well recognized, of course, that any individual is the result of the reaction of its genotype to the environment in which it develops. When a pure line is being used, all of the individuals belong to the same genotype. It is reasonably certain that the strains used for such investigations as are outlined below are pure lines. The seed is the result of inbreeding over a number of generations; there is no

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indication of any segregation with morphological characteristics; and, if high and low variates are used to raise another generation, the characteristics of each progeny are similar, and also similar to those of the parent generation. The variation exhibited amongst the individuals of such a line must therefore be attributed to the environment.

Many efforts have been made to control and make uniform the environment in which each individual is grown, but, no matter to what extremes the investigator goes, or what precautions are taken, the variation in the pure line still exists, although not to such a marked degree when such measures are adopted. Such measures deal with the environment from sowing onwards, but it must be remembered that the individual—the seed—has already partly grown, and the environment under which the seed is developed must be considered. Seeds taken from the same ear of a wheat plant are different. Pollination and fertilization do not take place simultaneously, and therefore the seeds do not commence development at the same time. Thus the various stages in the maturation of the individual seeds are exposed to different environments. Further, these seeds are in different spikelets and in different parts of the same spikelet, and under such conditions it is naturally to be expected that the seeds are unlike. Simple measurements of weight and size of seed, length and breadth of embryo scar, &c., will show the extent of the variation present. These measurements will not record any variation with regard to weight of embryo, chemical composition, &c. During the migration processes, it may happen that certain compounds or elements tend to be transferred before others. If so, it is reasonable to assume that the early maturing seeds will be richer in such products. Even if the nutrient stream be constant, seeds of different ages may absorb the nutrients at unequal rates. In any case, it is quite possible that there are physiological as well as morphological and anatomical differences in seeds of the same pure line. These differences (non genetic) are regarded as being due to predetermination because they may predetermine, to a certain extent, the course of the development of an individual after the germination of the seed.

There is some evidence in the literature available to support these ideas. Engledow (1923) has shown that there is a higher nitrogen content in the younger seeds, and Beaven (1920) has found that seeds with a high nitrogen content give more tillers than others.

Richardson and Green, in 1916, conducted an experiment on the centgener system. The individual seeds were weighed, and later this weight was compared with the yield of the subsequent plants. They report, inter alia, that "the median kernels of the spikelets are invariably lesser in weight and impoverished, and if they germinate they produce less prolific plants."

Kiesselbach (1925) reports an experiment conducted over a four-year period, in which "500 large and 500 small seeds of Turkey wheat were space planted 6 inches apart to permit maximum development of individual plants. These two grades, which were selected each year from a commercial variety, averaged 3.57 and 1.32 grams per 100 seeds respectively. The plants from the larger seed averaged 5 per cent. greater height, 9 per cent. more stools, and 23 per cent. greater yield of grain per plant. Very small seed is less productive than large seed when given opportunity for maximum development."

Kiesselbach also reports that, over a ten-year period, large and small seeds were selected from a commercial sample of the variety Turkey Red, and two experiments were conducted each year, one in which the same weight of each size of seed was sown per plot at the ordinary rate of planting, and the other in which equal numbers of seeds per plot were sown. The results showed that where equal numbers of seeds were sown—the larger being sown at the ordinary weight per acre—there was a slight increase in yield in favour of the larger seed, the acre yields being 35.7 bushels for large and 32.8 for small seed. Where equal weights of seed were sown, the difference was not so marked—for large the yield was 35.7, and for small 34.3 bushels per acre. This result might be accounted for by Kiesselbach's explanation above. He concludes that there will be no material or practical gain in grain yield, under farm conditions, from the practice of grading small grain seed which is reasonably free from trash and inert matter.

In order to investigate the effect of the various attributes on yield, and to determine the mode of inheritance of such attributes, it is desirable to eliminate or reduce the effects due to environment. This may be done in one or two ways, or by a combination of both—(i) to reduce the variation due to environment, or (ii) to measure the effect of such variation, and to make allowance for it in the results. It is impossible to eliminate the effects due to predetermination, and in this case the only alternative is to measure its effects. The primary difficulty is to determine just what are the differences which are due to predetermination, and which affect subsequent growth. In all considerations for genetic purposes, the seed must not be destroyed; therefore only characteristics which would permit of this being done could be considered. Experiments were designed and carried out in 1931, 1932, and 1933 to examine the effect of certain characteristics.

In the first place, it was considered that size of embryo might be important, but, unfortunately, it could not be determined without destroying the seed. However, there was the possibility that the size of the embryo might be related to the time of blooming, and that those seeds which developed in early blooming flowers might have larger embryos than others. It was decided to set up a "time of flowering" experiment to test this possibility.

1. "Time of Flowering" Experiment 1931-1932.

In 1931, three apparently normal plants of the variety "Baroota Wonder" were chosen for the experiment. Two plants had four, and the other had three good ears. At flowering time, each of the first three flowers of each spikelet was examined at 9 a.m. and 2 p.m. every day until it had bloomed, and the period in which blooming had occurred was carefully recorded. The plants were allowed to mature in the normal manner, and were then harvested. From the ears, the following data were recorded:—

(*a*) The position of the seed in the spikelet, ear, and plant;
(*b*) the time of flowering of the seed (recorded at flowering time);
(*c*) the length of the ear;
(*d*) the weight of the ear;
(*e*) the weight of each seed; and
(*f*) the length of each seed.

In 1932, these seeds were sown at random in a small plot in which the rows were 6 inches apart, and the seeds 2 inches apart in the rows, adequate guards being provided. Since an Engledow dibbler was used, the spacing was quite even. The plants were grown to maturity, and then harvested. The following additional data were recorded:—(*g*) date of brairding; (*h*) date of earing; (*i*) date of flowering; (*j*) date of ripening; (*k*) period of maturation; (*l*) number of ears; (*m*) dry weight of plant; (*n*) weight of grain from the whole plant and main ear; (*o*) number of fertile spikelets from the whole plant and main ear; and (*p*) number of grains from the whole plant and main ear.

Analysis of Data.

From the data obtained, many correlations between the various characteristics were determined. There was no significant correlation between time of flowering of the seed and the following characteristics in the subsequent generation:—Maturation period; dry weight; number of ears; yield, average weight per grain, and number of grains or number of fertile spikelets per plant; yield, number of grains, or number of fertile spikelets per main culm. The actual value of the correlation of time of flowering and plant yield was —0.106 with a value of *P* of 0.10. With regard to seed weight, no significant correlation was found between this characteristic and maturation period, average weight per grain per plant, yield, or number of fertile spikelets per main culm. Significant correlations were found as follows:—

—	*r.*	"*P.*"
Seed weight and yield per plant	+ 0·3824	< 0.01
„ „ number of ears per plant	+ 0·3484	„
„ „ number of fertile spikelets per plant ..	+ 0·3872	„
„ „ number of grains per plant	+ 0·3857	„
„ „ number of grains per ear	+ 0·1817	„
„ „ number of grains per main culm ..	+ 0·2580	„
„ „ dry weight of the whole plant	+ 0·3554	„

Other significant correlations were found, but as these are immaterial to this discussion they need not be mentioned.

From the results, it is seen that there is no significant relationship between time of blooming in individual flowers of a plant and the yield of plants in the next generation. However, seed weight is definitely correlated with the individual result of the succeeding generation. The increase in yield due to seed weight is brought about in the first place by an increased number of ears per plant, and secondly by an increase in ear size as shown by the correlation between seed weight and number of grains per ear. (The average weight per grain was not affected significantly, for this characteristic and seed weight $r = -0.05$ and $P. = 0.4$). The partial correlation between seed weight and number of grains per ear, holding number of ears constant, is 0.2338, and is significant.

2. Experiment 1933.

In view of the positive results obtained in 1932, it was thought possible that further information might be obtained with regard to predetermination, and that the size of the embryo as measured by the size of the embryo depression might be related to yield.

Some ears were taken from one plant of the variety "Waratah," the grains removed, and data similar to those in 1932 taken, with the addition that the length and breadth of the embryo depression were recorded. These measurements were made with an eyepiece micrometer under a binocular. The seeds were sown on moist sand in petri dishes, and the amount of growth after 44 hours was recorded. They were then sown at a uniform depth in a small plot in rows 6 inches apart, with the seeds 2 inches apart in the rows. The height of the plants sixteen days after planting was observed, and after harvest the dry weight and the value of the usual yield components was determined.

Again, correlations between the various characteristics were calculated, the results being as shown below:—

Correlation between—	Value of *r*.
Seed weight and embryo length	+ 0·6017 *S**
" " embryo width	+ 0·7417 *S*
" " product of embryo length and width	+ 0·7438 *S*
" " rate of germination	− 0·1041
" " early growth	+ 0·2807 *S*
" " number of ears per plant	+ 0·3664 *S*
" " number of grains per ear	+ 0·1687 *S*
" " average grain weight per ear	+ 0·0899
" " yield	+ 0·3976 *S*
Embryo length and rate of germination	+ 0·0613
" " early growth	+ 0·3276 *S*
" " number of ears per plant	+ 0·2635 *S*
" " number of grains per ear	+ 0·1302 *S*
" " average grain weight	+ 0·0831
" " yield	+ 0·2876 *S*
Embryo width and rate of germination	− 0·0406
" " early growth	+ 0·3389 *S*
" " number of ears per plant	+ 0·2656 *S*
" " number of grains per ear	+ 0·1669 *S*
" " average grain weight	+ 0·0407
" " yield	+ 0·2985 *S*
Product of embryo length and width and rate of germination	+ 0·0394
" " " " early growth	+ 0·3329 *S*
" " " " number of ears per plant	+ 0·2946 *S*
" " " " number of grains per ear	+ 0·1516 *S*
" " " " average grain weight	+ 0·0691
" " " " yield	+ 0·3245 *S*
Rate of germination and number of ears per plant	+ 0·0923
" " number of grains per ear	+ 0·0679
" " average grain weight	+ 0·0286
" " yield	+ 0·1042
Early growth and number of ears per plant	+ 0·3464 *S*
" " number of grains per ear	+ 0·1667 *S*
" " average grain weight	+ 0·0262
" " yield	+ 0·3987 *S*
$n = 320$	

* "*S*" in this column indicates that the correlation is significant.

From the point of view of predetermination, the analysis shows that seed weight (*w*), the product of the length and width of the embryo scar (*em*), and early growth (*h*), each is correlated significantly with the yield of the subsequent plant, whereas rate of germination is not.

The partial correlation of yield with embryo size, eliminating seed weight, as measured by the scar, is +0.06, which is not significant, thus indicating that taking embryo size into consideration does not account for any more of the variation than is already accounted for by seed weight. The partial correlation of yield with early growth eliminating seed weight is + 0.328, which is significant, and indicates that early growth is correlated with subsequent yield apart from any correlation between seed weight and yield.

The multiple regression of yield on seed weight and early growth is—

Yield = 0.497 seed weight + 0.358 early growth.

The value of the multiple correlation *R* is +0.49. From this, it can be concluded that 24 per cent. of the variance in yield is correlated with seed weight and early growth.

The amount of early growth was measured sixteen days after planting, and as all seeds were treated as uniformly as possible, i.e., were given an apparently similar environment, it is considered that the differences in the early growth are due to differences in the seed, and not to any slight differences in environment. Support for this belief is forthcoming also from the fact that, if seeds of a pure line are germinated under uniform conditions in a petri dish, then in a period of ten to fifteen days there is quite a variation in the height (early growth) of the seedlings. It is very unlikely that such differences are due to external environment, and it must be concluded therefore that they are due to predetermining factors. Hence at least 24 per cent. of the variance in yield is due to predetermination.

It is interesting to determine the effect of these predetermining influences on the various yield components, number of ears per plant (*e*), number of grains per ear (*n*), and average weight per grain per ear (*g*).

Both seed weight and early growth are significantly correlated with ear number and number of grains per ear, but not with average weight per grain. The determined value of *r* for *e* and *n* is —0.0465, which is not significant, and the partial correlation co-efficients, *r.wn.e* and *r.hn.e*, are +0.20 and +0.19 respectively, both being significant. These predetermining influences therefore have a direct effect on grain number as well as ear number. A value of *r.eh.w* = + 0.276 shows that the effect of the factors associated with early growth affect ear number apart from any association between early growth and seed weight. An analogous conclusion can be drawn with respect to grain number per ear for *r.hn.w* = + 0.126, which is significant.

From another experiment in which the varieties "Waratah" and "Garnet" were used, the correlation between seed weight and yield for "Garnet" was + 0.136 (not significant), and for "Waratah" +0.325, which is significant. The average weight of the "Garnet" seed used was 18.66 mg., and of the "Waratah" 23.22 mg.

Although there is a positive correlation between seed weight and the yield of the individual plants in the subsequent generation, the value of this to the farmer has not been shown. In the three examples investigated, it will be noted that plants from seeds of different size were grown alongside one another for comparative purposes, the relative positions of the plants being determined by randomization. If heavy seeds can give their seedlings a good start, then plants derived from these get ahead of those from lighter seeds, and are in a much more favorable position to compete with their less fortunate neighbours. This would be reflected ultimately in yield, and thus the differences due to predetermination are really brought about by unfavorable competition, due, of course, in the first place to differences in seed weight.

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Tick Paralysis: A Fatal Disease of Dogs and other Animals in Eastern Australia.

*By I. Clunies Ross, D.V.Sc.**

The work on tick paralysis discussed in the article that follows was originally undertaken as a co-operative enterprise between the University of Sydney and the Dog Tick Research Association. The latter is a private body that has been established in New South Wales to encourage the investigation of what is a troublesome disease in certain parts of that State. Following the erection of the Council's F. D. McMaster Animal Health Research Laboratory in the grounds of the University, the dog tick work has been accommodated in that Laboratory, where it is under the immediate direction of Dr. Clunies Ross. The article is but a brief summary of the work done. It is hoped to publish a full account at a later date.—ED.

Summary.

Paralysis caused by the tick *Ixodes holocyclus* is a condition that affects human beings (mainly children) and dogs, as well as other animals. It is prevalent along the east coast of New South Wales and Queensland.

Evidence has been obtained that the disease is caused by the injection of salivary secretion of the tick following a period of four to five days' engorgement on its host.

An immunity to the disease has been found in a few dogs under natural conditions. The serum of these particular animals appears to be useful as a curative agent for the treatment of affected dogs.

Effective control measures are (i) the daily removal of ticks from animals exposed to infestation, and (ii) the use of tick repellants. Derris is a satisfactory repellant.

1. Introduction.

Tick paralysis is a disease affecting all domesticated animals, but particularly dogs, throughout eastern Australia, from northern Queensland down to the Victorian border. Mortalities due to ticks have been reported in man (principally infants), foals, calves, pigs, sheep, dogs, cats, and poultry. In contrast, native fauna, at least those in infested areas, appear to be immune.

Of all these animals suffering from tick paralysis, dogs, and to a lesser extent, cats, are most seriously affected, and the mortality amongst the former around the city of Sydney alone may amount to many hundreds, or even thousands in a single year.

The tick responsible in Australia is in all cases *Ixodes holocyclus*. A condition similar to the Australian is seen in other countries, but there it is caused by such ticks as *Ixodes pilosus, Dermacentor venustus, D. andersoni,* and other species.

(i) *The Distribution of Ixodes holocyclus.*

Tick paralysis is only seen along a narrow coastal belt of country, this in many places being not more than 10 miles in width, though extending somewhat further inland in the warmer regions of the north

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coast of New South Wales and tropical Queensland. In no case, however, does its inland distribution approach that of the cattle tick, *Boophilus australis,* or the Central Queensland dog tick, *Rhipicephalus sanguineus* (?).

This very limited distribution appears to depend on the great susceptibility of *Ixodes holocyclus* to slight variations in temperature, and particularly humidity. In the vicinity of Sydney, the rainfall decreases rapidly as one leaves the coast, so that even 20 miles inland it may be little more than half that of the metropolitan area, and with this decline the incidence of the tick falls very rapidly.

Another factor governing the incidence of the tick is the presence of the bandicoot (*Perameles* spp.). These small marsupials are always found heavily parasitised, are its most important hosts, and are possibly necessary for the survival of the species. Bandicoots abound along the foreshores of Sydney Harbour and in the northern suburbs.

(*ii*) *Life History.*

Ixodes holocyclus is a three host tick engorging on a separate warm-blooded host as a larva, a nymph, and an adult. The period of engorgement of each stage normally lasts from five to six days, and on completion of engorgement the immature forms abandon the host, and undergo further development to the next stage on the ground.

On abandoning the host, the adult female tick proceeds, after a variable period, to lay from 2,000 to 3,000 eggs; she then dies. The male has only one purpose in life, and is quite an innocuous creature, never attaching to a host or sucking blood, though frequently being found on dogs' coats or human clothing.

(iii) *Nature of Tick Paralysis.*

The great majority of cases of tick paralysis are caused by the adult female, and a single female may be capable of causing the death of the largest dog. However, where dogs are infested by large numbers of nymphs, paralysis may also occur on rare occasions, though the few cases the writer has seen of this nature have not been fatal. Nevertheless, it is said that dogs do sometimes succumb to such attacks.

The larvae have not been known to cause definite paralysis, but they give rise to a very great local irritation and nervous prostration in human beings, who may become infested with many hundreds at one time owing to the mass hatching of eggs, and the presence of great numbers of larvae in a limited area.

The disease caused by the tick is characterized by rapidly ascending motor paralysis, which usually affects the hindquarters, and then involves the forelegs so that the dog becomes unable to stand, or even raise itself. The muscles of the neck and head finally become affected. Respiratory embarrassment is generally a marked feature of serious cases, and death is mostly due to respiratory paralysis.

All efforts to demonstrate anything in the nature of an infective micro-organism as the causal agent have failed.

One striking characteristic of the disease is that the onset of paralysis is never seen before the end of the fourth, or the beginning of the fifth, day, when, as is usually the case, only one or two ticks are attached to a dog. This period corresponds to the onset of, or final rapid stage of, engorgement of the tick, and has been shown to be

accompanied by marked increase in the size and activity of the salivary glands of the parasite. The coincidence of the onset of paralysis with the final stage of engorgement of the tick is also seen in those forms of tick paralysis observed in South Africa and Canada.

2. The Source of the Causal Agent of the Disease.

As has been mentioned, the salivary glands of the tick undergo great enlargement during the final stages of engorgement, and attempts have therefore been made to determine whether the toxic principle is present in the salivary secretion. By dissection of numbers of five-day ticks, which have gorged on dogs, and the emulsification of the salivary glands, it has been found possible to obtain a solution which, if injected into white mice, will regularly produce fatal results and characteristic symptoms of tick paralysis. It has been possible, moreover, to determine the mouse minimum lethal dose of this pooled salivary emulsion for white mice, as the equivalent of $2\frac{1}{2}$ to 3 glands.

Attempts have also been made to see whether the fact that paralysis does not occur before the fifth day is due to quantitative factors, namely, the failure to produce a sufficient quantity of salivary toxin prior to this, or to some qualitative change which occurs in the secretion during the later stages of engorgement. To determine this question, large numbers of three and four-day ticks were dissected, and it was found that by sufficiently increasing the number of glands injected, fatal results could be obtained with salivary emulsion of ticks of both ages. It would appear, therefore, that the onset of paralysis is determined by quantitative rather than qualitative factors.

This finding suggested the possibility that, if a sufficient number of ticks were attached to suceptible dogs, paralysis might be induced in less than the previously ascertained minimum period of four full days. On investigation, it was found that when 30 ticks were allowed to attach to a small puppy weighing only $6\frac{1}{2}$ lb., paralysis was induced at the beginning of the fourth day, even though the ticks were removed at the end of the third day. In a slightly larger puppy (approximately 9 lb. weight), no symptoms were seen before the end of the fourth day after similar treatment.

It will be seen, therefore, that the possibility exists of paralysis occurring, particularly in very small animals, in less than four days. In practice, since infestation usually occurs with only a small number of ticks at one time, little danger exists in this short time. This point is of very great practical importance, since if a dog owner is prepared to examine his dog daily, and remove all ticks found, he has at least four chances of finding any one tick before it is able to cause paralysis.

3. The Search for Remedial Agents.

(i) *Immunity and the Production of a Hyper-immune Serum.*

Many dogs are credited with what is considered to be either natural or acquired immunity to tick paralysis. Many such dogs are not immune, but are merely known to have had ticks gorge upon them without producing disease symptoms, as not infrequently occurs even in quite susceptible animals. There is no doubt, however, that a considerable number of dogs in tick-infested areas are in possession of a very

high degree of immunity, whatever its nature may be. This suggested either that the serum of such dogs might be used for curative purposes, or that other dogs might be actively immunized. Investigation of these points was therefore instituted.

We were fortunate in being presented early with two immune dogs—a large Airedale and a Black Retriever, both of which were found to be capable of resisting 40 or 50 ticks engorging upon them at one time. The serum of one of these animals was tested experimentally as a preventive agent, and was found, in 5 ml. doses, to have definite protective value for puppies on which ticks were allowed to engorge completely immediately following the injection of serum. As might be expected, no lasting protection was conferred in this way.

Later, on the determination of the minimum lethal dose of salivary secretion for white mice, the anti-toxic titre of the serum of both dogs was determined by its power to neutralize salivary toxin. The serum of both dogs, shortly after large batches of ticks had gorged upon them, was capable of neutralizing 20 to 40 minimum lethal doses per millilitre. The serum of these animals has since been used to treat over 100 cases of naturally occurring tick paralysis, and, of one of them, to treat a small number of experimentally-induced cases.

In these experimental cases, though the number of animals is admittedly small, it was found that, in 10 ml. doses, the serum was of value in curing paralysis induced by a single tick, whereas control puppies, litter mates of the treated animals, succumbed. In the naturally-occurring cases, though one is not able to be dogmatic in the absence of controls, the evidence points to the serum also being of definite curative value, about 75 per cent. of all cases showing definite paralysis prior to treatment recovering. This is in contrast to the varying estimates of private veterinarians, for all cases treated by them therapeutically, of a recovery rate of 10 to 60 per cent., and excludes also those cases which were showing only mild and unprogressive symptoms when treated.

Unfortunately, the anti-toxic value of these two immune dogs' serum falls very rapidly when ticks are not allowed to engorge upon them at frequent intervals, and it is necessary therefore to ensure that large batches of ticks are available to engorge upon susceptible animals more frequently than once a month. In contrast, however, these dogs may remain immune to paralysis themselves, even though no ticks have been placed upon them for at least six months.

To determine whether such immunity might in some cases be due to the natural or inherited resistance, puppies of a hyper-immune mother mated with a hyper-immune father have been tested, and all found to be no less susceptible to paralysis than other puppies. This suggests, therefore, that the immunity is wholly acquired, although it is quite possible that factors as the size of the dog, constitution, &c., may play some part in conferring resistance to fatal effects or disease.

Though it appears possible to build up an active immunity experimentally by allowing ticks to engorge for a short period of time on susceptible puppies, it has not so far been found possible to avoid risk in so doing, so that this method is not yet capable of general application.

The possibility exists that the larger animals, such as sheep and horses, may be immunized, thus facilitating the production of immune serum for curative purposes on an adequate scale. However, owing to

the number of ticks required to induce a high anti-toxic value in dogs, as also the difficulty in obtaining regular engorgement on larger animals, this line of attack has not been prosecuted.

(ii) *Tests of Tick Repellants.*

(*a*) Search has been made for some repellant substance which might be applied externally to a dog so as (*a*) to kill all ticks which are attached, and (*b*), if possible, to confer some temporary immunity to further attack. A number of popular remedies said to possess these qualities, such as a frequent administration of sulphur internally, of various baths, &c., have been tested, but without any useful result.

(*b*) *Tests of Derris Preparations.*—In view of the widespread use of preparations of derris for parasiticidal purposes, tests of the value of derris powder, as also one of its active principles, rotenone,* were early carried out. It was soon seen that ground derris root, either applied as a dusting powder, or as a cold water infusion, was highly lethal for ticks. Experiments with cold water infusions were first carried out with 10 per cent. and 5 per cent. infusions of crude ground root, but, subsequently, a 1 per cent. infusion of sieved powder was found to be effective, not only in killing ticks already attached, but for those attaching subsequent to treatment. Infusions are made by soaking 1 per cent. of derris powder by weight in cold water overnight, and the following morning adding sufficient soap or soap powder to make a good lather before use. By one application of such solutions, or of the dry powder when rubbed well into the coat, newly-attached ticks will be found dead or dying in four to eight hours, but semi-gorged specimens may remain alive for 24 hours, though in almost every case they are obviously sick in this time, and then gradually dry up and ultimately fall out.

Infusions also have been found, in practically every instance, to kill all ticks attaching during the next 72 hours after bathing, and in a majority of cases all those attaching up to 96 hours, or sometimes longer. In view of the fact that it requires at least four days for small numbers of ticks to cause paralysis, if almost complete immunity to attack by ticks is given for 96 hours by one application, then by repeated applications once a week, a high degree of immunity to tick paralysis should be conferred.

To test this belief, small susceptible puppies were run in an area of heavy tick infestation for seven weeks, one being powdered with dry powder, one being bathed with a 1 per cent. infusion as mentioned above, and one with a 2 per cent. infusion, all treatments being given once a week. Control puppies which were untreated were also run at intervals with the others.

The first control died after 8 days; the second control died 14 days after replacing the first, and the third control 7 days after replacing the second. All the other puppies remained quite healthy, although ticks were found on three occasions at the end of the week on the puppy bathed in the 1 per cent. infusion.

At the end of the seventh week, the animals were not re-bathed, and on the eighth day after the last bath the puppy previously bathed in the 1 per cent. infusion developed tick paralysis. It may be noted,

* The rotenone used was very kindly supplied by Professor Macbeth, University of Adelaide, and had been extracted from samples of *Derris* spp. from New Guinea, which he had found to have a 5 per cent. rotenone content.

however, that five days prior to this, torrential rains fell, and all puppies were wet, which might be expected to wash out any water-soluble fractions or powder deposited in and remaining on the coat.

From dog-owners' reports, derris preparations appear to be no less effective against the dog-tick of Central Queensland, *Rhipicephalus sanguineus* (?).

It would appear, therefore, that weekly application, either of derris powder in dry form, or as a 1 per cent. soapy cold water infusion, will confer a high measure of protection against tick infestation. It is not suggested, however, that because of this, dog-owners should neglect the more obvious measure of looking for and removing all ticks found, a measure which, if conscientiously carried out as a daily routine, will of itself confer immunity to attack.

One precaution is necessary where reliance is placed on derris preparations alone, and that is that ticks may still attach to the edges of the eyelids or the inner canthus of the eye. Owing to the absence of hair in these places, there is nothing to hold the active principles for any length of time. In addition, where the wash is used, since it is not wise to wet the inside of the ear, special care must be taken to examine this part for ticks, or, as an alternative, the inside of the ear may be dusted with dry powder. It must also be clearly appreciated that applications of derris will only confer protection if conscientiously applied. Thus, the wash must thoroughly wet every part of the body, and penetrate the matted coats of long-haired dogs. The powder must be worked into the coat over the whole body, on the legs and between the toes, and not dusted casually on the head and neck.

It may be noted that derris powder is not as non-toxic as is frequently stated, and caution must be exercised in applying the powder to cats, particularly Persians, and long-haired toy breeds of dogs. Owing to the excessive quantities sometimes applied to such animals, and the likelihood of some quantity being swallowed, symptoms of gastric irritation have been observed. At times also, the eyes may become inflamed, and care should be exercised in preventing the wash or the powder entering them. Persons applying the powder should also guard against inhaling it.

With the demonstration of the value of the serum of hyper-immune dogs for curative purposes, and the protective value of derris powder, it is felt that considerable advance has been made in the attack on a problem than which there is none affecting dogs more serious or fatal throughout the coastal belt of eastern Australia.

4. Acknowledgments.

This work has been carried out as a co-operative investigation by the Dog Tick Research Association, which has supplied the funds, the University of Sydney, which has supplied accommodation and the assistance of certain of its officers, and the Council for Scientific and Industrial Research.

The writer would like to express his appreciation of the invaluable help which has been given him by Dr. H. R. Carne, and particularly by Mr. D. A. Gill. To the latter a very great measure of credit is due for the success so far attained in these investigations.

Research on Bees: Progress Report II.

*By G. A. Currie, B.Sc., B.Sc.Agr.**

A brief note in regard to the objects of the Council's investigations on bees, and in regard to the grant, by the Commonwealth Bank from its Rural Credits Development Fund, that has been made available for the purpose of that work, was given in a previous issue (see this *Journal*, 4: 253, 1931). Attention was drawn in that note to the fact that the Australian bee industry is responsible for a production worth £100,000 per annum, based on official statistics alone; that Apiarists Associations consider the industry annually produces very much more than that amount, as there are numbers of beekeepers holding relatively small areas, from whom no statistical returns are obtained, and that the industry is apparently capable of considerable expansion if certain disabilities, including dwindling, can be overcome. Work on the problem of dwindling is carried out by the Council as opportunity offers from time to time. The article that follows is the second report on that work, the first report having been published in 1932.—Ed.

Summary.

It has been reported already that certain mixtures of commercially available protein substances, when fed to bees in the absence of natural pollen, led to the development of the brood-food glands in nurse bees, and that bees could be reared on these substances from the egg to the adult stages under scientifically controlled conditions. These results were obtained in laboratory and insectary experiments.

Experiments have now been conducted during a period when natural pollen was absent in the field, by placing pollen substitutes mixed with thin honey or syrup inside the hives. Such artificial feeding led to brood rearing at a time when brood was normally absent from the hives. Feeding with syrup or honey alone did not produce this result.

In early spring, before natural pollen was available outside, substitutes (milk products) mixed with bran, were placed in trays in the open. Bees accepted the dried milk and casein, but would not accept white flour, and reared brood on both of the former substances. Some stored pollen was present in the hives at the time, but the control apiary reared brood at a slower rate than the experimental hives.

Experiments in the field carried out by beekeepers in collaboration with the Division of Economic Entomology showed that dried milk mixed with other substances, e.g., pea flour, maize and wheat germ meal, bran, or cocoa, given in trays in the open, gave enhanced brood rearing when pollen was scarce, or absent.

Costs and quantities are discussed, and lines of future work indicated.

1. Introduction.

After having succeeded in rearing bees from egg to adult stages under experimental conditions,† and having carried out a considerable number of laboratory experiments to test the value of various pollen substitutes for the development of brood-food glands in "nurse" bees, the next step was to carry out extensive field experiments.

Apiarists in various parts of the country have tried many different substances as substitutes for pollen, some claiming success and others failure with the same substances. Unfortunately, most of these tests

* An officer of the Division of Economic Entomology, C.S.I.R.

† Research on Bees: A Progress Report. *J. Coun. Sci. Ind. Res.* 5: 81, 1932.

were carried out without controls or careful observations. Nevertheless, the experiences of practical men are invaluable when open to unequivocal interpretation.

If a very serious pollen famine over a wide area had appeared during the period, a large scale experiment would have been conducted to try our various substitutes. However, no such pollen famine eventuated, although numbers of localized pollen famines were reported from time to time, usually too late for experiment. Indeed, one of the most striking features of the research was the frequency of relatively short period, localized, pollen famines, particularly in the inland areas of lower rainfall, from which the bulk of the high class, yellow box honey comes. Coastal areas with higher rainfall and more varied flora suffered less frequently from pollen shortages.

In the absence of a wide-spread pollen famine, the following three lines of inquiry were pursued:—

(1) Selected hives were supplied with pollen substitutes inside the hives during a period when pollen was normally absent, and when brood rearing was normally in abeyance.*

(2) Pollen substitutes were placed out in trays for bees to collect in the very early spring before pollen was normally available. Control hives in the same class of country were given no pollen substitute.†

(3) Experiments were carried out in collaboration with apiarists in New South Wales, Victoria, and South Australia, and the results collated.

2. Feeding Substitutes Inside Hives.

The period chosen for these tests was from the third week of April onwards, when outside pollen was normally absent in Rushworth (Victoria), where the tests were carried out.

A preliminary test was commenced on 18th April. A hive with no brood and no pollen (pollen having been removed) was given sugar syrup mixed with casein powder—1 oz. casein to 1 lb. syrup—inside the hive. A control hive was given sugar syrup only.

Brood rearing started immediately in the casein fed hive, while the control hive, given syrup only, and the hives not fed at all, remained at the same level of declining brood rearing as before. A few eggs were laid in the "syrup only" hive, but the resulting larvae were poorly supplied with brood-food, while the larvae in the hive supplied with casein were fed copiously with brood-food "just as they are when a young queen starts laying in spring," as Mr. Morgan reported it. A very little pollen was available from the garden flower *Cosmos* at this particular time.

Following this very definite preliminary result, a more extensive series of tests were set out, using seven different substitutes mixed with thin honey, and the same series mixed with sugar syrup. Hives of about the same strength and the same age and race of queens were selected for the feeding tests. The materials were all mixed at the rate of 1 oz. of the substitute to 1 lb. of thin honey or sugar syrup.

* The experiments in which bees were fed inside the hives were carried out by Mr. Morris Morgan, then President of the Victorian Apiarists' Association.

† The external feeding experiments were conducted by Mr. D. M. Morgan, of Rushworth, Victoria.

Mixtures used were as follows:—

A. Dried milk.
B. Dried milk—1 part; white flour—2 parts.
C. Dried milk—1 part; pea flour—2 parts.
D. Dried milk—4 parts; wheat flour (whole meal)—8 parts; yeast (dried)—1 part.
E. Dried milk—4 parts; pea flour—8 parts; yeast (dried) 1 part.
F. Fresh cow's milk.
G. Fresh white of egg.

One set of controls were fed thin honey or syrup only, and another set of control hives were not artificially fed. Every day each hive was given as much as it would take of the food, and examinations of brood were carried out as often as weather permitted.

In previous tests, casein was found to cause development in the brood-food glands of "nurse" bees, and to stimulate brood rearing. On casein alone, however, the young bees reached the pupal stage, but failed to emerge adult. Some mixture with other materials such as bran, wheat germ meal, pea flour, cocoa, or some natural pollen, was necessary in order to raise bees to the adult stage. Whole milk was more "complete" in itself, but the essential requirements have not yet been fully worked out.

The area covered by brood of all ages, capped and uncapped, was calculated, and the quantities are shown as fractions of whole standard frames in the accompanying graph.

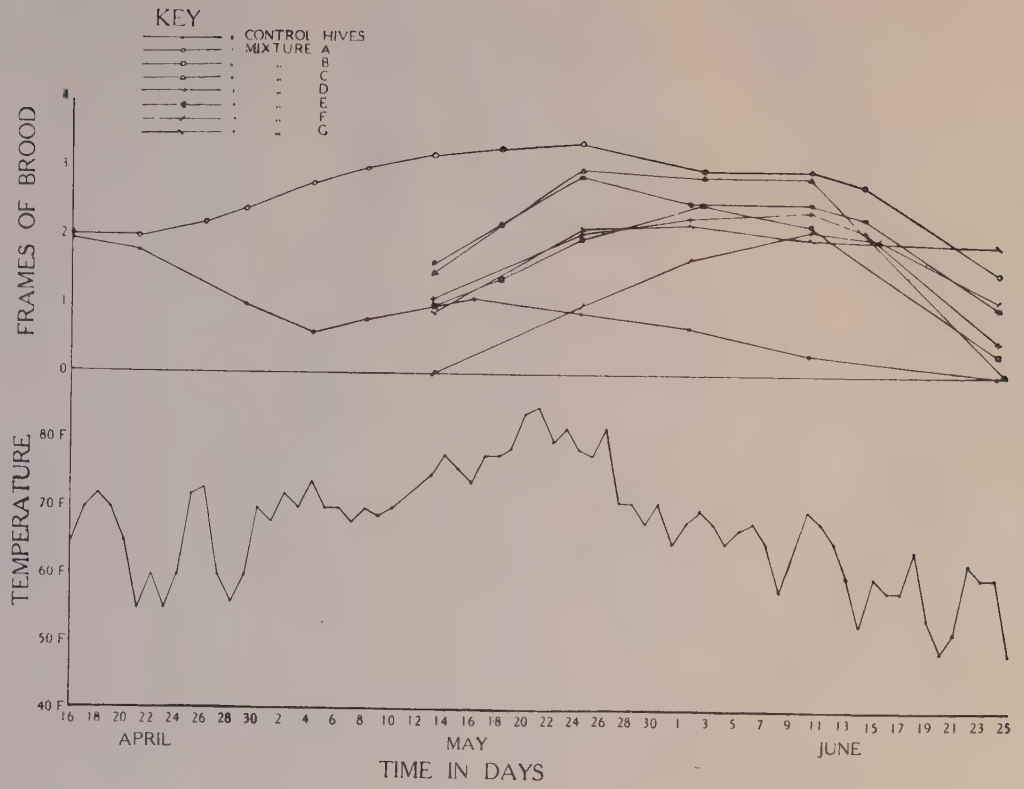
It will be seen that, whereas the control hives had almost ceased brood rearing by 4th June, the artificially fed hives increased their brood rearing, and ceased only when the weather became so cold towards the end of July that they did not accept the food offered.

Development of Brood-food Glands.

From time to time during the experiment, the condition of the brood-food glands in bees from the different hives was ascertained. In order to get a comparative figure for the state of development of the brood-food glands, the following arbitrary standard was adopted. For glands fully developed, 6 points were allowed, and for atrophied glands having no brood-food in them, 0 points were given. All the gradations from 0 to 6 were represented by the appropriate figures. In each hive, 20 bees were examined, and allotted points in accordance with this arbitrary standard.

The total points for the 20 bees of each hive are shown. The numbers in the upper line represent the hives fed substitute plus sugar syrup, and in the lower lines those in which substitute was added to thin honey.

Mixture.	A	B	C	D	E	F	G	..	..
Sugar	100	59	60	78	59	52	98	Check 1—30	Check 2—47
Honey	96	90	72	80	44	52	100	,, 3—50	,, 4—50
Total points ..	196	149	132	158	103	104	198	80	97


KEY
CONTROL HIVES
MIXTURE A
B
C
D
E
F
G
FRAMES OF BROOD
0
1
2
3
TEMPERATURE
40 F
50 F
60 F
70 F
80 F
16 18 20 22 24 26 28 30 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 1 3 5 7 9 11 13 15 17 19 21 23 25
APRIL
MAY
JUNE
TIME IN DAYS

As stated already, parallel sets of experiments were carried out, one set being given sugar syrup with the pollen substitute, while the other was given thin honey with the same substitute. There were no significant differences in the results obtained from the use of these two materials, so in most instances they have been calculated together. Whenever differences did appear, there were obvious local reasons for them, apart from the differences in feeding. This gives the order as follows:—

A. Dried milk	196
B. Dried milk + White flour	149
C. Dried milk + Pea flour	132
D. Dried milk + Whole meal Flour + Yeast	158
E. Dried milk + Pea flour + Yeast	103
F. Cow's milk	104
G. White of egg	198
Check hives	84

So far as stimulating the brood-food glands into action is concerned, the results shown in the table suggest that the dried milk and the white of egg have considerable value. The other materials in mixture with the dried milk appear to have acted merely as diluents, the development of glands being roughly in proportion to the amount of dried milk present in any one mixture.

It should be borne in mind, however, that for actual *brood rearing*, as shown in the graph, this did not hold true, so that great caution is necessary in interpreting these results.

The lack of definite advantage accruing from the use of dried yeast in the mixture is an anomaly for which no explanation is forthcoming at present.

Since these tests were completed, the author has had a communication from Myola K. Haydah, who, working at Minnesota, was able to rear bees through from the egg to the adult stage on meat-scrap meal in one set of experiments, and cotton-seed meal in another.

As soon as opportunity occurs, cotton-seed meal will be tested out by itself on a commercial scale in this country, but meanwhile dried milk or casein, mixed with pea flour, wheat germ, or maize germ meal, cotton-seed meal, cocoa, or bran, may safely be used during a pollen shortage with a good chance of benefit accruing.

Until meat-scrap meal has been tried for its possible odour in the hive, it appears inadvisable to use it with the risk of possible contamination of honey.

3. Feeding outside the Hive.

Two apiaries, each of 15 comparable hives, were placed out in forest country some miles apart, and beyond flight range of the home apiary of 180 hives, which was situated in similar forest country. Near one apiary, casein powder mixed with bran was put out in trays, and near the other white flour was similarly exposed. The home apiary was used

as the control. These preparations were made near Rushworth in July before the golden wattle trees had bloomed, so that no outside source of pollen was available to the bees. On warm days, the bees accepted the casein powder readily, collecting it along with the smaller particles of the bran. The white flour was refused, so, after a fortnight, it was replaced by dried milk powder, which the bees accepted at once.

Only a few days during July and August were suitable for the bees to fly and to collect the substitutes, but, in spite of this, brood rearing was more rapid in the hives provided with pollen substitutes than in the control hives of the home apiary. At the time in early August when the hives of the home apiary averaged one frame of brood to the hive, the apiaries provided with the pollen substitutes had an average of two frames of brood per hive. All hives had some pollen stored from the previous year.

When the golden wattle bloomed late in August, and the weather became warm enough for flight, the bees neglected the pollen substitute entirely to collect natural pollen.

4. Other Experiments.

When local pollen shortages were reported, opportunity was taken to carry out small tests in co-operation with bee-keepers in the various States. None of these has proved quite conclusive, but in every instance mixtures containing dried milk powder led to definite increases in brood rearing, when other conditions were suitable.

One apiarist* has obtained good results from a mixture of dried milk, pea flour, and cocoa powder. He reports as follows:—

> "In one apiary of 72 hives, where scarcely any natural pollen is available, the bees are taking about 2 lb. of substitutes per day. The hives have an average of 4½ well-filled combs of brood, and are getting stronger."
>
> "Another apiary of 36 hives has plenty of natural pollen, and the hives are getting stronger, having an average of 5 frames of brood per hive.
>
> "A third apiary in which very little natural pollen is available, not being given any substitute, has an average of 3½ frames of brood, and is diminishing in strength."

5. Cost of Substitutes.

In our inside feeding experiments, the costs of the materials used were as follows:—

Mixture.	*Cost.*
A	4·68 pence per hive per month.
B	2·18 „ „
C	2·23 „ „
D	6·26 „ „
E	6·45 „ „
F	7·5 „ „
G	8 „ „

The most costly material was the dried yeast; next, the white of egg, but this latter would be much cheaper during the spring and summer months. Dried milk powder can be obtained in fairly large bulk quantities at about 5d. per lb., but the price varies considerably in each district.

* Mr. B. Whiting, Copper Hill, New South Wales.

The amount of substitutes used varies with the rate of brood rearing. During the tests inside the hives, the bees used only an average of about ½ oz. of substitute per day per hive. When brood rearing is at its height, considerably more than this would be used.

It is not possible to say how much substitute would be required by the bees during a period of heavy brood rearing. Up to about ½ lb. of natural pollen per day may be used by a strong hive in the height of the breeding season, but it is unlikely that pollen substitutes would be accepted and used by the bees at this high rate. There is the further difficulty, in assessing quantities, in that the amount of pollen required to rear a certain number of bees may vary with the quality of the pollen, and also that a given weight of pollen substitute may produce a greater or a smaller number of bees than the same weight of natural pollen.

During a pollen shortage, it would appear safe to allow substitute at the rate of 1 oz. per hive per day, and to increase the quantity if the bees would accept more. In each particular instance when a pollen shortage occurs, the beekeeper would have to decide whether it would pay him better to move his bees into a more favorably situated area, purchase pollen-filled combs from another district, or feed pollen substitutes to his bees. The difficulty about pollen-filled combs seems to be that diseases may be transmitted by them, and that pollen may be stale unless the source is trustworthy. Each method will have its advantages under different circumstances.

6. Conclusion.

It is of interest to note that proteins of animal origin, notably those in milk, white of egg, and meat-scrap meal, have been successful in developing the brood-food glands of "nurse" bees, and have led to considerable brood rearing.

Those vegetable proteins which have proved to be of greatest value have been contained in natural pollen, cotton-seed meal, and yeast.

In mixtures, maize and wheat germ meal, pea flour, bran, and cocoa, have also some value in brood rearing.

Our experiments are producing increasing support for the theory that proteins which have been shown to be "complete" (i.e., containing all the essential amino-acids) for the growth of young mammals will also prove to be complete for the growth of young bees.

Consideration has not yet been given in these experiments to the vitamin content of the substitutes, though it is probable that these substances play some role in the economy of the hive.

Experiments will be continued to determine the most effective and cheapest substitute for pollen, and to study the development and functioning of the brood-food glands in worker bees.

7. Acknowledgments.

Thanks are due to Mr. Morris Morgan, editor of *The Australasian Beekeeper,* and to Mr. D. M. Morgan, for their whole-hearted co-operation, and to the many bee-keepers in Victoria, New South Wales, and South Australia, who spent time and effort in co-operative work.

For helpful criticism and suggestions in the preparation of the manuscript, thanks are due to Dr. A. J. Nicholson, Acting-Chief of the Division of Economic Entomology.

A Note on the Treatment of Tapeworm (*Moniezia* spp.) Infestation of Sheep.

*By H. McL. Gordon, B.V.Sc.**

1. Introduction.

Although it is now generally recognized that *Moniezia* spp. alone seldom causes serious pathogenic effects in sheep, owners frequently attribute loss of condition, and even mortalities, to these parasites, and accordingly demand a remedial drench. There is no doubt that, if present in sufficiently large numbers, *Moniezia* spp. may certainly be of some pathogenic importance, and in mixed infestations probably add to the effects of haemonchosis, trichostrongylosis, oesophagostomiasis, and chabertiasis.

A number of drugs and combinations of drugs have been recommended against these tapeworms. Combinations of copper sulphate and nicotine (in the form of Black Leaf 40) are usually recommended, but Freeborn and Berry (1934) consider that the efficiency of either constituent alone is low.

The observations recorded below were made firstly during an experiment dealing with the chemotherapy of oesophagostomiasis, and subsequently a special experiment was designed to deal with *Moniezia* spp. alone.

The experimental sheep were Merino lambs, eight to nine months old, carrying heavy naturally-acquired infestations with *Trichostrongylus* spp. and *Oesophagostomum columbianum,* and also carrying varying numbers of *Haemonchus contortus, Dictyocaulus filaria, Cooperia curticei, Nematodirus* spp., *Moniezia* spp., *Trichuris ovis, Meullerius capillaris,* and an occasional *Oesophagostomum venulosum* and *Chabertia ovina.* These lambs were very poorly grown, and were in an emaciated condition, in size and weight being about equal to some three months old lambs.

2. Experiment 1.

As stated above, this experiment was designed in connexion with the treatment of *Oesophagostomum columbianum* infestation. The drug employed was arsenic trisulphide ($As_2 S_3$), which Mönnig (1933) considered to offer promise of efficiency against this parasite in South Africa. In view of the findings of Clunies Ross (1934), that solutions of copper sulphate administered to sheep pass directly to the abomasum in the great majority of instances, it was decided to give arsenic trisulphide suspended in such solutions to some sheep, while to others the drug was given in powder form as done by Mönnig. One group received a full dose of magnesium sulphate following the dose of arsenic

* An officer of the Division of Animal Health C.S.I.R., who is located at the F. D. McMaster Animal Health Research Laboratory and engaged on work under the Australian Pastoral Research Trust—E.M.B. Scheme.

trisulphide shaken up in copper sulphate solution. Lambs were divided into four groups of five each:—

Group "A" received 0.5 gm. As_2S_3 in powder form.
Group "B" received 0.5 gm. As_2S_3 in 30 ml. 2% $CuSO_4$ solution.
Group "C" received 0.5 gm. As_2S_3 in 30 ml. 2% $CuSO_4$ solution followed by $MgSO_4$.
Group "D" received 0.25 gm. As_2S_3 in 30 ml. 2% $CuSO_4$ solution.

The lambs were treated on 7th July, 1934, at 10.30 a.m. after having been last fed the previous afternoon at 5 p.m. on lucerne hay. Water was available throughout. The lambs were again fed at 11.30 a.m. on 7th July. After treatment a calico bag was attached to each lamb in order to collect all faeces and worms passed. Egg counts previous to treatment had revealed *Moniezia* spp., and in all lambs except S477. Table I. shows *Moniezia* spp. passed after treatment. + indicates that *Moniezia* spp. were passed, — that faeces were negative for segments or eggs.

TABLE I.

Group.	No. of Lamb.	8th July, 1934.	9th July, 1934.	10th July, 1934, and subsequently.
"A"	450	+	—	—
	455	—	+	—
	462	—	+	—
	476	+	—	—
	478	+	—	—
"B"	449	+	—	—
	451	+	—	—
	454	—	+	—
	457	—	+	—
	466	+	+	—
"C"	458	+	—	—
	460	Dead		
	464	—	+	—
	472	—	+	—
	473	—	+	—
"D"	459	—	+	— until 16th August, 1934, when again became positive
	461	+	—	—
	471	+	+	—
	474	+	+	—
	477	—	—	—

Discussion.

S460 was dead on the morning of 8th July, 1934. At post-mortem, masses of *Moniezia* spp. were found in the ileum and caecum. Egg counts were made on faeces of these lambs for almost two months following treatment, and in only one case did ova of *Moniezia* spp. appear. This was in the case of S459. Daily egg counts made on the faeces of

this lamb from 8th July, 1934, onwards did not show *Moniezia* spp. ova until 16th August, 1934. S459 was treated on 21st August, 1934, with 0.5 gram. $As_2 S_5$ as powder, and on the following day passed *Moniezia* spp. segments. Subsequently, all the lambs in this experiment were killed, and at post-mortem were free from *Moniezia* spp.

It thus appears that the arsenious sulphide alone, or in the combinations used, was almost equally effective in removing *Moniezia* spp., S459 being the only exception. In this lamb, which received the smaller dose of arsenic sulphide, it appears that the scolex remained, and after approximately a month a new strobila had grown, and eggs were being produced. A second treatment of this lamb was quite effective. It is to be noted that S477 was negative for *Moniezia* spp. throughout.

3. Experiment 2.

This experiment was designed to compare the efficiency of arsenic trisulphide and copper sulphate against *Moniezia* spp. Six lambs were used and divided into two groups:—

Group "E" received 0.5 g. $As_2 S_5$ in powder form.

Group "F" received 30 ml. 2% $CuSO_4$ solution.

The preparatory treatment was as in Experiment I. The animals were treated on 17th July, 1934, at 11 a.m. The results are shown in Table II.

Table II.

Group.	No. of Lamb.	18th July, 1934.	19th July, 1934.	20th July, 1934.
"E"	475	+	−	−
	467	+	+	−
	453	+	+	−
"F"	470	+	−	−
	468	−	−	−
	463	+	+	+

S463 passed only stray mature segments. S468 was negative for *Moniezia* spp. throughout, and was included in the experiment without previous faecal examination having been carried out. The remaining lambs passed masses of *Moniezia* spp.

The six lambs were killed on 20th July, 1934, and all were completely negative for *Moniezia* spp., except S463, which had two mature specimens some yards in length. Careful search failed to reveal any retained scolices in the other lambs.

Discussion.

It appeared that arsenious sulphide in 0.5 gm. doses was 100 per cent. efficient in removing *Moniezia* spp., even when given alone in powder form, its action being quite rapid (within 26 hours). Copper sulphate solution in the strength used was quite efficient in one case, and quite inefficient in the other.

4. Conclusions.

Arsenic trisulphide is very efficient in removing *Moniezia* spp. from sheep, administered either in powder form or suspended in copper sulphate solution. Copper sulphate solution alone was efficient in one out of two cases.

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Blowfly Attack in Sheep: Its Prevention by Fold Removal (Mules' Operation).

*By H. R. Seddon, D.V.Sc.**

The brief article that follows has been published by the Council at the suggestion of the Joint Blowfly Committee, which is a body that has been set up to co-ordinate the blowfly research activities of the Council and of the New South Wales Department of Agriculture.—Ed.

As stated in Report No. 1 on the Sheep Blowfly Problem in Australia,† published in 1933, Mr. J. H. W. Mules, Woodside, South Australia, brought before the notice of the Council for Scientific and Industrial Research the fact that he operates on sheep to reduce their susceptibility to fly attack, and claimed good results following his procedure.

The manner in which the operation is carried out is detailed (and illustrated) in that report, but briefly may be stated to be the excision of the folds of the breech by pinching them with Burdizzo pincers, and then cutting them off inside the jaws with a sharp knife. The folds most prone to lead to strike are those which extend down each side of the breach, one on either side of the vulva. Elevated as they are, these folds are liable to be constantly wetted by urine, with consequent development of an area attractive to the fly. The operation is extended also to remove from about the breech any other folds which, from urine-staining of the wool, show what Mr. Mules terms "brown ends," and can, moreover, be extended further to deal with the upper parts of the above folds where they join the base of the tail. To test the value of the methods the writer, with the assistance of his co-workers, Messrs. H. G. Belschner and L. F. R. Bell, operated on some 116 lambs, retaining the same number untreated for a comparison of the results.

These lambs constituted the total drop from the flock of ewes at the Nyngan Experiment Farm, and, as regards susceptibility to blowfly attack, were a mixed lot. Ninety-one of the 232 were A class, and what would be regarded as plain crutched; nevertheless the side folds mentioned above were present to some degree in all of them. Some 41 of the lambs were of C type, i.e., markedly susceptible, whilst the remaining 100 were moderately susceptible.

An inspection of the lambs a month after operation showed that the wounds had healed well, that in most instances the whole of the folds had been removed as intended, but that better results could have been obtained in some cases had the skin fold excision been a little more extensive. (Naturally, it being the first time we had tried this procedure, and, fearing fly strike of the wounds caused, the operation was performed rather cautiously and conservatively). A comparison of the operated and control groups showed considerable difference, most of the former appearing as plain in the breech as the plainer of the latter.

The two lots of sheep were run together, and the early strikes recorded by Mr. L. F. R. Bell, later ones by Mr. R. E. Churchward. During the first year of the experiment, the operated group showed only 22.6 strikes per 100 sheep as against 70 in the controls—a reduction of

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† Report No. 1 by the Joint Blowfly Committee. Published as Pamphlet No. 37 of the Council for Scientific and Industrial Research, and as Science Bulletin No. 40 of the New South Wales Department of Agriculture.

over two-thirds. In the second season, there was no fly attack for some ten months, but during the following two months' strike was fairly severe. Nevertheless, there was only half as many strikes in the operated as in the control group. Following this, the flock was extensively culled on account of wool and body conformation, whilst a number died as a result of blowfly attack and other causes, so that the two groups remained no longer comparable.

It is thus seen that, taken broadly, the results were good, strike incidence being considerably reduced as claimed by Mr. Mules. A number of the strikes which occurred in the operated group might possibly have been prevented had the operation been carried out more efficiently, i.e., with more drastic removal of folds. In some cases, however, strike developed in animals of this group in situations which do not seem to lend themselves to operation by this means, i.e., strikes in the "dimple" at the end of the stump of the tail. (Strikes in this situation can largely be controlled by a modification of the tailing operation, as such a dimple is liable to result when the skin on the outer side of the tail is cut unnecessarily high up in an endeavour to cover the stump with non-woolled skin.) *Infolds* of skin are, of course, liable to be struck, and, as removal of adjacent *outfolds* causes a smoothing out of them by contraction of scar tissue, care should be taken to remove any out-folds in the vicinity of infolds.

Whilst the operation can be done with the Burdizzo pincers and knife, this method is slow, laborious, and severe on the instruments, the knife being rapidly blunted whilst the pincers are scored by its point. The use of sheep shears (as has been adopted by some, or of roll-cut or other secateurs) cannot, in my opinion, be recommended, as there is no preliminary crushing of the nerves, and hence loss of sensation prior to cutting. The ideal instrument for the operation has therefore yet to be evolved.

When efficiently carried out, the results from this operation should be good, inasmuch as by it the susceptibility of sheep can be considerably reduced, and it is understood that some owners have already put the operation into practice, at least on an experimental scale.

Fold removal is of advantage to the holder of the sheep from the lessening of fly attack in them. Such sheep, however, retain their inherent capacity for producing lambs more or less wrinkled in the breech according to the original conformation of the ewe and that of the sire used. As the operation leaves only a small linear scar at most, it is often hard to detect "operated" ewes, and to outward appearance, as in the yard, a line of such sheep will appear plain crutched. If, therefore, the operation becomes at all general, buyers might easily and inadvertently secure such sheep in the belief that they were in fact plain crutched, but find later that lambs from them possessed a breech wrinkling out of all proportion from what might have been expected from the appearance of the ewes and the conformation of the sire used.

This operation, therefore, like selective breeding, aims to produce sheep with plain breeches, such being recognized as a type of sheep least liable to crutch strike. That this may be done also by breeding, and yet wool quality and density retained, is realized by many, and practised by not a few. The fold removal operation, however, may have a sphere of usefulness in the treatment of those sheep actually possessing an inherent susceptibility to crutch strike, or where for some reason selective breeding for breech plainess is not possible or desired.

A Chemical Investigation of *Pinus radiata* in Relation to its Paper-making Qualities.

Part 1.—The Distribution and Nature of the Non-volatile Ether Extractives.

*By W. E. Cohen, B.Sc.**

Summary.

The question of the use of pines, such as *Pinus radiata*, for paper-making is one of great importance owing to the large-scale planting of these species in Australia and New Zealand. The presence of resinous material in some pines causes certain pulping troubles which hitherto have prevented their use in the paper industry.

Recent work has shown that these difficulties may be overcome where no heartwood has been formed. It was, therefore, decided to make a study of the resins in the sapwood and heartwood of *Pinus radiata*.

Consideration has been given to the distribution and nature of the non-volatile ether extractives of *Pinus radiata* by the examination of 85 samples collected from various localities in South Australia, Victoria, and New Zealand. The samples were obtained from trees of ages varying from 6 to 22 years.

The distribution and nature of the resin in the inner and outer rings, and the influence of the presence of heartwood on the resin content, have been examined. Other factors, such as the influence of resin ducts, seasonal variation, and the time of storage, have been discussed from the point of view of resin content. The behaviour of heartwood in sulphite pulping has also been discussed.

1. Introduction.

During the past decade or so, in both the Commonwealth of Australia and the Dominion of New Zealand, numerous afforestation companies have been formed, and have led to the planting of large areas of pines, mainly *Pinus radiata* (*insignis*). As an outlet for much of their products, pulpwood has been emphasized, even though little information on this technical problem has been obtained. In addition, the various State forest services are building up plantations of *Pinus radiata*, and a suitable outlet for the resultant thinnings and mill waste is very desirable.

In spite of their extensive occurrence in many parts of the world, resinous woods of the genus *Pinus* so far have not been used on a commercial scale as raw material for the sulphite pulp and newsprint industries. They are readily treated by the alkaline pulping processes, such as the soda and sulphate cooks, but, under acid-cooking conditions, it has been found that pitchy substances frequently occur in the resulting pulp. (The use of alkaline processes is not always desirable on account of the high costs sometimes involved in the subsequent bleaching, and for that reason the acid processes are generally preferable.) There seems to be little doubt that the above-mentioned pitchy substances have as their origin some polymerization or similar process which readily takes place under the acid conditions of the cook.

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and which involves the oleoresins peculiar to the genus. Thus, Konopatzky (1) has come to the conclusion that the origin of the troublesome "pitch" is the solvent, and subsequent precipitating, action of such materials as terpenes, "xymol," &c., on the real resinous material, which is thereby deposited on the surface of the fibres in the form of a sticky "wet" material causing the trouble during the subsequent processing of the pulp. He considers that the trouble has its origin during the pulping process, and should, therefore, be remedied at that stage. It is recorded that efforts to remove the pitchy materials during the bleaching process only result in a high bleach consumption.

However, with some pine woods, the remedy seems to lie in the wood itself, or rather the selection of it. Thus, Benjamin and Somerville (2) have reported a successful laboratory treatment by the sulphite process of well-grown *Pinus radiata* wood at 15 to 20 years of age. However, a fairly high bleach consumption was experienced. There is no record of the occurrence of heartwood in the wood treated, and it is possible that very little, if any, was present. They stated that the wood carried practically the same amount of resin as spruce, which would suggest that the amount of heartwood was not very great.

More recently, the successful treatment for sulphite pulp and newsprint, of pines growing in the southern parts of the United States of America, has been indicated by a series of announcements. Firstly, Winslow (3) discussed the possibilities of using a modified sulphate process for the production of a white kraft paper, and referred to improvements that could be applied to the sulphite process. Then Herty (4) outlined experiments on young Southern (Georgian) pines (up to 10 years) in which sulphite pulp and groundwood had been successfully produced without any "pitch" troubles. This success resulted from the treatment of green sapwood only, for heartwood gave unsatisfactory results. Herty expressed the opinion that it was not the acids in the wood which caused pitch trouble. His experiments were described more fully by MacNaughton and Allen (5), who concluded that previous objections to the use of pine woods, on account of the high resin content of the heartwood, were founded upon a failure to differentiate between the sapwood and heartwood of the southern pines, and to appreciate the large diameters to which the trees could grow before the transformation from sapwood to heartwood begins. They discussed the resin content of young slash pines, and showed it to be of the order of 2 per cent. They referred to the much earlier observations of Roth (6), who concluded that in longleaf pine, the transition from sapwood to heartwood rarely begins in trees below 20 years of age. They quoted numerous results of analyses of various pines which, on examination, suggest that there is little significance between the amount of heartwood and the resin present as indicated by the ether-extractive content. Details of the sulphite pulp and groundwood experiments were given. Subsequently, Romel (7) gave details of the sulphite pulping of numerous Georgian pines (mostly young growth and thinnings).

Hence, it can be taken for granted that pine wood which is free from heartwood can be used without difficulty for the preparation of sulphite pulp and groundwood, although the commercial possibilities have yet to be determined. On the other hand, with heartwood present, pitch troubles may be expected from pulp prepared by the sulphite process. Curran and Bray (8) have overcome this difficulty to some

extent by employing a rather expensive modified sulphate cook. Quite recently, it has been reported that Herty (9) has completed experiments which showed that groundwood can be satisfactorily prepared from pines 50 years of age, and containing heartwood. This would suggest that the heartwood resins will give no trouble unless modified by some chemical treatment.

There is sufficient evidence already to hand to indicate that, so long as there is no heartwood present, *P. radiata* could be used successfully for sulphite pulp and newsprint, though the economics of the process are as yet undemonstrated. There is no evidence, however, to show the age at which the transformation from sapwood to heartwood in this timber commences. Hence, it is very necessary to determine this age, and also under what conditions the oleoresins increase in quantity and change in their chemical nature in such a manner as to form pitchy substances under acid-cooking conditions.

Some consideration has already been given to the variation in distribution and constituents of the oleoresins of several species of the genus *Pinus*. Generally, the ether-soluble material has been regarded as representing the oleoresins. Petroleum ether has also been used as the solvent, but has given lower yields, whereas alcohol, acetone, and alcohol-benzene have introduced other undesirable water-soluble substances. Consequently, most studies have involved an examination of the ether extractives.

Kurth and Sherrard (10) record an examination of the distribution of ether-extractive in slash pine. Trees from stands of various ages, ranging from 11 to 25 years, were examined, and these included both slow- and fast-grown as well as wide- and closely-spaced trees. The green wood was extracted, and on all occasions the ether extract was tested for acid and saponification values, and for unsaponifiable residue. This study indicated differences in the nature of the extracts from sapwood and heartwood. The latter consisted mainly of resin acids, while the former, apart from being present in much smaller quantities, consisted of acids which were substantially diluted with esters. There were variations in extractive content from pith to sap, and also, at the centre of the trunk, with height above ground.

The above-mentioned investigation was subsequently extended to include turpentined trees (11), and revealed that, apart from around the wounded area, there is no material difference in the amount or composition of the extractive from that in un-terpentined trees. More recently, Kurth (12) has continued the study to include longleaf and shortleaf pines, and the results obtained were analogous to those obtained with slash pine.

Bishop and Marckworth (13) have employed an altogether different method, using benzene as solvent, in the study of the sapwood of second growth loblolly and slash pines. Their observations indicated that the resin content varied according to the minimum prevailing temperature, particularly when below 40 deg. F., and that the best time to cut the trees for pulping purposes would be during the winter, following a sudden drop in temperature. This does not sound very practicable for a wood pulping project. They also obtained indications that a decrease in resin could be correlated with an increase in moisture content, and vice versa. Taken over a period of time, the average benzene-soluble resin content of the sapwood was found to be in the vicinity of 3 per cent. on the dry wood basis.

The studies which have been reviewed above indicated an increase in extractive and a change in its chemical nature during the transformation from sapwood to heartwood. Furthermore, the transformation from sapwood to heartwood usually did not commence before the trees were 20 years of age. In the case of *P. radiata,* it seemed important to study the distribution and nature of ether-extractive, and the occurrence of heartwood in trees of ages varying from six years to over twenty years collected from various localities.

2. Material Used.

Samples in the form of log sections (6 inches to 12 inches in length) were obtained from butts of trees of the following ages—6, 8, 10, 12, 14, 16, 18, 20, and 22 years. The samples were collected in the following localities:—

South Australia.—Mt. Burr State Forest.

Victoria.—Bright, Forests Commission Plantation (6-16 years); Mount Macedon, Forests Commission Plantation (18-20 years).

New Zealand.—Canterbury Region, Otago Region, Dusky and Conical Hills Districts, Puhipuhi, Waipoua, and Riverhead Districts, Pataruru, Rotorua Conservation Region, Kaingaroa, Whakarewarewa and Waiotapu Districts.

The unbarked samples were packed in crates free from packing material in order to minimize any infection by blue stain, and were despatched to the Division of Forest Products as soon as possible after collection. Information relative to conditions of growth, climate, aspect, and altitude was forwarded by the collectors. Upon their receipt at the laboratories, the samples were immediately prepared and dried so that any blue stain infection could not develop further.

3. Experimental Procedure.

(*a*) *Preparation of Samples for Analysis.*—Each log section was trimmed at the ends in order to remove wood which had been in immediate contact with the air. When more than one sample was taken from a log section, these were selected to cover a specified number of annual rings. Where heartwood occurred, this was included with the inner ring samples. When only one sample was taken, this was selected in the form of a sector, and included all annual rings.

Preliminary extractions of green samples with ether resulted in the deposition in the extraction flask of a brownish flocculent deposit, which was obviously not soluble in ether. It was subsequently found to be insoluble in alcohol, but readily soluble in water. In addition, it was found impossible to break up the green wood to a uniform and small enough size to produce satisfactory duplicate results. For these reasons, all samples before extraction were dried in a vacuum oven at 55-60 deg. C., and reduced by means of an impact mill to a size comparable with sawdust.

(*b*) *Extraction with Ethyl Ether.*—Approximately 80 grams of each powdered sample was extracted for 24 hours with dry acid-free ether. The extractions were carried out in relays, the samples being charged into ether-extracted thimbles. Duplicate extractions were made

on all samples. The residual wood was freed from excess solvent by suction, and the extract solution evaporated by distillation. Both wood and extract were dried in the vacuum oven at 55-60 deg. C. before being weighed. The yield of extractive was expressed as a percentage of moisture-free, volatile-free, and ether-extractive-free wood. The resulting extracts were tested for acid and ester numbers.

(*c*) *Acid Number.*—This determination, together with the subsequent ester number, was carried out in Erlenmeyer flasks (Chance's resistant glass) which were thoroughly cleaned and steamed out between determinations. On account of the relatively small quantities of extract, it was necessary to pay particular attention to errors that might be introduced by the glass vessels employed. The acid number was determined by titration of the warm alcoholic solution of the extract, using half normal potassium hydroxide and phenolphthalein indicator.

(*d*) *Ester Number.*—The neutral alcoholic solution from above was evaporated to remove alcohol. The ester number was then determined by saponification of the residue with a measured excess of half normal alcoholic potassium hydroxide for two hours. The excess alkali was titrated with half normal hydrochloric acid, using phenolphthalein indicator. Blanks were run with each batch of saponifications.

(*e*) *Sulphite-cooking Tests.*—These were made by the Chief Chemist of the Australian Paper Manufacturers Proprietary Limited, using the apparatus described by Benjamin and Somerville (2). The cooking conditions employed for the sapwood sample were identical with those already developed for young well-grown wood of *P. radiata.* For the heartwood sample, a longer penetration period and a steeper temperature gradient were necessary in order to avoid a completely raw cook.

4. Discussion of Results.

The results are set out in Tables 1 and 2, and Fig. 1. Those in Table 1 show that there is a definitely greater amount of ether-extractive in the inner rings of all log sections examined. In the few cases where the inner rings contained much heartwood, this difference between inner and outer rings was very pronounced, e.g., in the 18-year sample from South Australia, in which the extractive increased from 0.22 per cent. for the outer rings to 4.98 per cent. for the inner rings. Only a few of all the samples examined in detail had developed heartwood to any extent, i.e., the 16, 18, and 20-year samples from South Australia, and the 16-year sample from Victoria.

The nature of the resin in the inner rings, as indicated by the acid to ester ratio, only differs from that in the outer rings when heartwood is present. Although the resin content increases towards the centre of the tree, the percentage of acid in the resin remains practically constant. However, as soon as heartwood is formed, this is accompanied by a pronounced increase in the acid content.

When sectors representative of all rings in a log section were examined, it was found that unless heartwood was present, there was no marked increase in resin content with age (see Table 2). An increase in resin content frequently coincided with the presence of heartwood, but this was not invariably true (see Table 2). Of two 14-year trees from the same locality (Puhipuhi), one contained about three

times as much heartwood (10 per cent.) as the other (3.5 per cent.), and yet there was little difference in the ether-extractive yields (0.37 and 0.42 per cent. respectively). Then a 14-year sample from another locality (Riverhead), which contained 9.5 per cent. heartwood, only yielded a fifth as much extractive (0.5 per cent.) as did a 16-year sample from the same locality (2.17 per cent.), which contained only 2 per cent. of heartwood. Hence, for the whole log section, there seems to be no relationship between resin content and the percentage of heartwood (see Fig. 1).

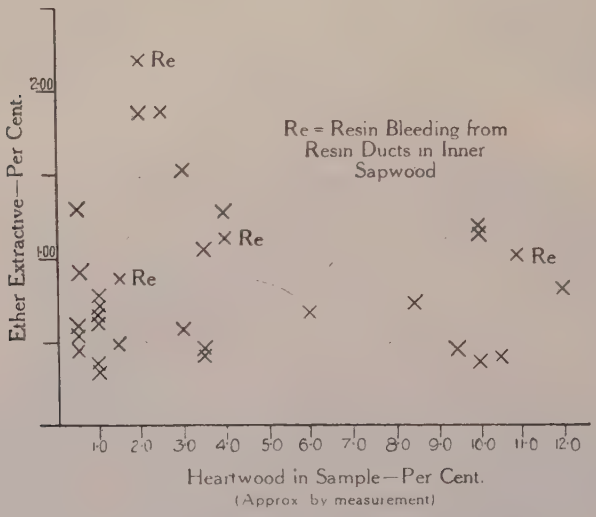

Fig. 1.—Demonstrating the absence of a relationship between percentage of heartwood in a sample and the ether-extractive yield.

In the above-mentioned 16-year sample, which yielded 2.17 per cent. of resin, bands of resin ducts, from which resin freely flowed on a freshly cut face, occurred in the inner sapwood rings. These bands occurred in many of the samples examined, and were noticed in samples from trees as young as ten years. Their occurrence, however, was more general at sixteen to eighteen years. Observations indicated that the resin from these contained a high percentage of esters. Thus, in the 18- and 20-year samples from Mount Macedon (see Table 1), the acid to ester ratio was considerably less than 1, which was contrary to the general run of results. Where these resin rings occurred, increased yields of extractives were found. Hence the reason for the high result (2.17 per cent.) mentioned above.

One factor of some interest is that from several young (6 to 8 year) samples, relatively high yields of extractive were obtained, e.g., from an 8-year sample from the Otago region, New Zealand Table 2), 2.06 per cent., and from a 6-year sample from Patarura, New Zealand (Table 2), 1.22 per cent. In these cases, it was found that the ether solution of the extract was of a bright green colour. Another point of interest is that the 18- and 20-year samples from Mount Macedon (Table 1) gave this green extract solution, in which, as already mentioned, there were more esters than acids.

A further matter of interest relates to the samples from South Australia (Table 1). The younger samples (i.e., 6-12 years), which were collected in March, showed a very low acid to ester ratio as compared with the older ones, which were collected in September. It is possible that time of collection affects results. In addition, changes during storage have been indicated, and these also probably affect results.

The pulping tests were carried out on samples from a 22-year tree, the heartwood of which yielded ten times as much ether extractive as did the sapwood. The sapwood yielded, with a normal cook, 46 per cent. of screened pulp and 11 per cent. of screenings. The pulp gave no pitch trouble when beaten. The heartwood, with a longer penetration period, a steeper temperature gradient, and a longer cooking time, yielded just over 30 per cent. of screened pulp and 23 per cent. of screenings. The pulp was highly resinous, and continued washing with water failed to improve it. On examination subsequently, the pulp from sapwood yielded 0.35 per cent. of ether extractive (saponification number 93, and acid to ester ratio, 2.9), while the heartwood pulp yielded 3.84 per cent. of extractive (saponification number, 172, and acid to ester ratio, 3.1).

5. Conclusions.

Very few definite factors have been revealed by the study. There seems to be no definite relationship between the yield of extractives from a whole log section and the age of the tree, or the presence of heartwood. The results obtained indicate the need for the examination of a much larger number of trees, including studies in relation to seasonal variation and changes in the extractives during storage.

Laboratory tests using sulphite pulping procedure have indicated that pinewood containing appreciable amounts of heartwood will be difficult to pulp, and will give rise to " pitch " trouble.

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TABLE 1.—DISTRIBUTION AND NATURE OF THE NON-VOLATILE ETHER EXTRACTIVES IN BUTT LOG SECTIONS FROM *Pinus radiata* TREES OF VARIOUS AGES.

Stated Age of Tree (years).	Log Section Details.		Sample Details.			Ether Extractive Details.			
	Diameter without Bark (inches).	Total Ring Count.	Location in Log Section (rings).	Average Rate of Growth (rings/inch).	Heart-wood present (approx.).	Yield Per Cent. †	Acid Number. *	Ester Number. *	Ratio Acid/Ester.
			Locality: Mt. Burr State Forest, South Australia.						
6	4·25	6	All	2·7	..	0·56	70	100	0·70
8	6·1	8	All	2·6	..	0·33	84	91	0·92
10	5·8	10	All	3·7	..	0·51	81	100	0·81
12	6·8	12	All	3·6	..	0·40	75	89	0·84
14	7·0	14	8 outer	6·0	..	0·32	120	82	1·46
			6 inner	2·0	..	0·74	132	55	2·40
16	6·9	15	8 outer	7·2	..	0·35	128	63	2·03
			7 inner	2·3	8.0	1·12	153	39	3·92
18	9·4	18	9 outer	4·5	..	0·22	112	38	2·95
			9 inner	3·0	25.0	4·98	156	22	7·09
20	8·25	20	13 outer	6·5	..	0·24	97	60	1·62
			7 inner	1·8	7.0	0·53	115	50	2·30
			Locality: Bright and Mt. Macedon State Forests, Victoria.						
6 (br)	5·3	6	All	2·3	..	0·43	130	42	3·10
8 (br)	4·75	8	All	3·4	..	0·42	120	52	2·31
10 (br)	7·25	12–13	4 outer	2·7	..	0·38	121	53	2·28
			9 inner	4·2	..	0·31	108	46	2·35
12 (br)	8·75	12–13	7 outer	1·75	..	0·40	143	52	2·75
			6 inner	2·5	1.0	1·26	149	30	4·97
14 (br)	10·75	15	10 outer	2·5	..	0·59	150	35	4·29
			5 inner	1·8	1.0	1·04	152	34	4·47
16 (br)	11·0	16	9 outer	3·0	..	0·55	144	56	2·57
			7 inner	2·2	6.0	0·71	142	46	3·09
18 (m)	9·75	14	6 outer	2·0	..	0·74	64	115	0·56
			8 inner	2·8	1.0	1·26	71	108	0·66
20 (m)	11·4	18	10 outer	3·3	..	0·65	82	107	0·77
			8 inner	2·6	..	1·00	66	120	0·55
			Locality: Canterbury Region, New Zealand.						
6 (h)	3·9	6	All	3·1	..	0·83	140	54	2·59
7 (h)	4·0	7	All	3·5	..	0·60	136	54	2·52
10 (h)	6·5	10	4 outer	3·1	..	0·56	127	45	2·82
			6 inner	3·1	..	0·91	135	45	3·00
12 (ba)	5·6	12	All	4·3	..	0·61	143	52	2·75
15 (ba)	5·75	15	All	5·2	..	0·68	141	43	3·28
17 (h)	7·75	17	8 outer	4·9	..	0·34	121	61	1·93
			9 inner	4·0	2.0	1·09	143	42	3·41
18 (h)	7·25	17	9 outer	6·0	..	0·29	112	60	1·87
			8 inner	3·8	..	1·75	147	31	4·74

NOTES.

* Expressed as mgms. of KOH per gram of dry extract.

† Expressed as a percentage of moisture-free, volatile-free and ether extractive-free wood.

Samples collected at (br) Bright, (m) Mt. Macedon, (h) Hanmer plantation, and (ba) Balmoral plantation.

In samples from Mt. Macedon (m), all rings in the sapwood exuded resin from ducts after a fresh cut, and the ether solution of the extract was bright green in colour.

TABLE 2.—TOTAL YIELD OF NON-VOLATILE ETHER-EXTRACTIVES FROM ALL RINGS OF BUTT LOG SECTIONS FROM *Pinus radiata* TREES OF VARIOUS AGES.

District.	Stated Age of Tree (years).	Sample Details.				Yield of Ether Extractive Per Cent.*
		Diameter without Bark (Inches).	Total Ring Count.	Average Rate of Growth (rings/inch).	Heartwood present (approx.). Per Cent.	
Locality: Otago Region, New Zealand.						
Dusky	8	7·5	8	2·1	..	2·06
„	8	5·5	8	2·9	..	1·26
„	10	6·0	10	3·3	..	1·61
„	10	6·6	10	3·0	..	1·40
„	12	6·4	11	3·4	..	1·01
„	12	6·0	12	4·0	..	1·19
„	14	8·9	14	3·1	..	0·86
„	14	8·0	13	3·2	0·5	0·92
„	16	9·4	16	3·4	..	1·01
„	16	7·5	15	4·0	..	0·92
„	18	7·75	16	4·1	3·0	1·52
„	18	9·4	18	3·8	..	1·07
Conical Hills ..	20	7·4	18	4·9	..	1·34
„ „ ..	20	7·25	20	5·5	..	0·90
„ „ ..	22	9·4	22	4·7	2·0	1·87
„ „ ..	22	7·75	22	5·7	0·5	1·28
Locality: Puhipuhi, Waipoua, and Riverhead Districts, New Zealand.						
Riverhead	6	3·9	5	2·6	..	0·28 (*a*)
Waipoua	8	9·0	7	1·6	..	0·64
Riverhead	10	5·0	10	4·0	..	0·70
„	14	7·25	13	3·6	9·5	0·45
Puhipuhi	14	5·1	13	5·0	10·0	0·37
„	14	6·1	13	4·2	3·5	0·42
Riverhead	14	5·25	14	5·3	3·5	0·47 (*b*)
„	16	5·4	17	6·3	2·0	2·17 (*c*)
„	18	9·0	17	3·8	3·0	0·56
Locality: Pataruru, New Zealand.						
Pataruru	6	6·0	6	2·0	..	1·22 (*d*)
„	6	4·4	4	1·8	..	0·66 (*d*)
„	6	6·5	6	1·8	..	0·87 (*d*)
„	8	6·5	7	2·2	..	0·88 (*d*)
„	8	8·6	7	1·6	..	0·67 (*d*)
„	8	8·5	8	1·9	..	0·54 (*d*)
„	10	12·8	10	1·6	..	0·52 (*e*)
„	10	15·8	10	1·3	0·5	0·44 (*e*)
„	10	12·3	10	1·6	..	0·57 (*e*)
„	12	8·5	12	2·8	0·5	0·58 (*e*)
„	12	12·8	11	1·7	..	0·68 (*e*)
„	12	10·3	12	2·3	2·5	1·88 (*e*)
„	16	12·3	15	2·5	10·0	1·69 (*e*)
„	16	12·3	15	2·5	12·0	0·80 (*e*)
„	16	13·3	15	2·3	10·0	1·65 (*e*)
„	18	14·0	17	2·4	10·5	0·41 (*e*)
„	18	13·5	17	2·5	6·0	0·66 (*e*)
„	18	14·0	18	2·5	8·5	0·72 (*e*)
„	20	12·0	19	3·2	4·0	1·29 (*d*)
„	20	11·8	19	3·2	3·5	1·03 (*d*)
„	20	12·5	20	3·2	1·5	0·88 (*c*, *d*)

TABLE 2—*continued.*

District.	Stated Age of Tree (years).	Sample Details.				Yield of Ether Extractive Per Cent.*
		Diameter without Bark (inches).	Total Ring Count.	Average Rate of Growth (rings/inch).	Heartwood present (approx.). Per Cent.	
Locality: Rotorua Conservation Region, New Zealand.						
Kaingaroa	8	5·5	7	2·5	..	0·64
„	8	5·4	6	2·3	..	0·56
„	10	5·9	9	3·1	..	0·84
„	10	6·9	8	2·3	..	0·72
„	12	7·1	14	3·9	1·0	0·77
„	12	7·4	11	3·0	1·0	0·70
„	14	7·5	12	3·2	0·5	0·53
„	14	7·6	12	3·1	1·0	0·65
Whakarewarewa ..	16	7·0	14	4·0	..	0·47
„ ..	16	7·4	15	4·1	1·0	0·60
„ ..	18	8·1	17	4·2	1·0	0·32
„ ..	18	8·5	18	4·2	..	0·60
„ ..	20	8·0	14	3·5	11·0	1·01 (*c*)
„ ..	20	7·9	17	4·3	1·0	0·38
Waiotapu	22	9·9	22	4·5	4·0	1·14 (*c*)
„	22	10·9	19	3·5	1·5	0·49

NOTES.

* Expressed as a percentage of moisture-free, volatile free, and ether-extractive-free wood.

(*a*) Sample blue-stained throughout; (*b*) ringshake, containing resin, present in this sample; (*c*) resin exuded from ducts in inner rings after fresh cut; (*d*) samples from healthy standing trees of normal development; (*e*) samples from self-sown, open-grown shelter trees.

Reversion of Selected Strains of a Wheat Variety.

*By H. Fairfield Smith, B.Sc.Agr. (Edinburgh), M.S.A. (Cornell).**

Summary.

Eighty strains of Turkey Red wheat obtained from single plant selections at Nebraska, in 1907, were grown in yield trials between 1910 and 1922. The resulting yields were published in a bulletin of the Nebraska Experiment Station. Examination of the published data indicates that there were marked differences in yield between the selected strains in the years immediately following selection, but that these differences gradually disappeared in subsequent years. Fourteen to fifteen years after selection the yields from all strains were equal to that from the original variety. Further data from similar selections made in 1902 suggest that selection of five to forty best plants out of each strain each year was unable to check the reversion.

The observations have important bearing on plant breeding practice and methods. It is suggested that any experiment stations having comparable data should have them examined for any indication of similar changes.

When reviewing literature in connexion with research on yield of wheat varieties, the writer had occasion to study in detail extensive data published by Kiesselbach in Bulletin 31 of the Nebraska Agricultural Experiment Station.† During the study, it was noticed that the yield of selected strains of Turkey Red wheat, which were markedly different in yield soon after selection, seemed to revert to the parental yield level after a few years. If this represents the common mode of behaviour of selected strains, the information is obviously of great importance in relation to plant breeding practice. The data were therefore further analyzed to test the statistical significance of the apparent reversion.

In 1907, 80 single plant selections were made from the wheat variety Turkey Red. Stocks of seed were obtained from these by growing in "increase rows" in 1908 and 1909. From 1910 to 1918 (except 1913), they were grown in yield trials having ten replications in each year, and with the original variety as a check in every fifth or sixth plot. Thirty-one strains were continued for four more years until 1922. From 1910 to 1912, each plot consisted of a single row; from 1914 to 1922, a plot consisted of five rows, of which only the centre three were harvested. (Although the effects of competition have been shown at Nebraska to be capable of interfering with the validity of results from single row plots of different varieties, the data for 1910-12 have, nevertheless, been considered admissible in the present case, because we have to deal with strains which were all derived from the same variety, which all eared and ripened on the same dates, and which varied by only about 2 inches in height.)

The published data give the mean yields for each strain in each year, and an estimate of experimental error may be obtained from the data on check plots. In Table 1 of this paper are shown the mean squares between means of 32 strains in each year (31 selected strains

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† Kiesselbach, T. A., Nebr. Ag. Expt. Sta., Res. Bull. 31 (1925).
‡ Kiesselbach, T. A., Nebr. Ag. Expt, Sta., Res. Bull. 13.

TABLE 1.—ANALYSIS OF VARIANCE FOR 31 STRAINS AND CHECK, CONSIDERING EACH YEAR SEPARATELY, ALONG WITH THE MEAN YIELD OF ALL STRAINS.

1. Year	1910.	1911.	1912.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.	1922.
Mean square between strains (31 degrees of freedom)	* 52·46	** 15·02	** 30·39	** 23·34	* 21·41	11·81	** 30·70	1·91	** 6·99	*† 3·07	1·04	1·86
Mean square for Error (calculated from checks: 9 degrees of freedom)	13·61	2·92	6·03	1·25	6·03	5·88	3·62	1·13	1·16	·68	·84	2·95
Z ($P = ·05$ for $z = ·525$) ($P = ·01$ for $z = ·766$)	·675	·818	·808	1·464	·633	·349	1·069	·262	·898	·753	·108	·232
2. Standard deviation between strains (corrected for experimental error) ..	6·23	4·59	4·94	4·70	3·92	2·44	5·20	·88	2·42	1·55	·45	0
3. Mean yield of all strains	51·8	54·2	35·0	46·3	48·1	57·8	28·5	9·1	23·7	30·9	28·2	28·3

* $P < ·05$.
** $P < ·01$ $r_{12} = -·89$; $r_{12·3} = -·83$.
*† $P < ·02$.

plus the check—calculated from data in Table 10 of the bulletin), along with the variance for error estimated from check plot data (Table 11 of the bulletin). Statistically significant differences between strains are shown for the years 1910 to 1915, 1917, 1919, and 1920.

In order to study changes of variance between strains, it was deemed advisable to deal with the inter-strain standard deviations corrected for experimental error (*vide* Smith*). These standard deviations were correlated with the year numbers, and with the mean yields of all strains. (Mean yield was considered, because it was thought that it might reflect some of the environmental factors whose variations may tend to increase or diminish strain differences.) The co-efficients of correlation obtained were:—

$$r_{12} = -·89^{**} \qquad r_{12·3} = -·83^{**}$$
$$r_{23} = -·57 \qquad r_{23·1} = -·09$$
$$r_{31} = -·67^{*\dagger} \qquad r_{31·2} = -·44$$

where $n^1 = 12$

The negative correlation of inter-strain standard deviations with years is definitely significant, and indicates that differences between strains diminish in successive years.

Careful examination of the data indicates that neither the method of selecting the 31 strains out of the original group of 80 strains, nor competition between single row plots in 1910 to 1912 affected these results to a measurable degree.

* Smith, H. F. Investigations on Analysis of Wheat Varieties I., Appendix 3. (unpublished). The method of correcting inter-class mean squares for experimental error has been described by Tippett, "Statistical Methods" London (1931) Section 6.2.
** Indicates $P < ·01$.
*† Indicates $P < ·02$.
(1) Denotes the year.
(2) Denotes the inter-strain standard deviation.
(3) Denotes the mean yield of all strains.

The changes in yield of strains relative to yield of the original variety are shown in Table 2. It seems that the selected strains tend to revert back to the same yield as the original variety. From row 3 giving the annual differences from the check of the four strains which seemed the best in 1914, the correlation co-efficient of these differences with their respective years may be calculated to be $r = -.67$ ($n^1 = 11$, $P = .025$) for 1911 to 1922. (Figures for 1910 are omitted because in that year the check seems to have given an exceptionally low yield, thereby perhaps exaggerating the greater yield of the strains in this

TABLE 2.—DIFFERENCES FROM THE CHECK (ORIGINAL VARIETY) OF THE MEAN YIELDS OF VARIOUS GROUPS OF STRAINS IN EACH YEAR.

1. Year	1910.	1911.	1912.	1914.	1915.	1916.	1917.	1918.	1919.	1920.	1921.	1922.
2. Yield of check (bushels per acre)	34·3	52·2	29·8	43·3	44·5	51·5	29·3	9·2	22·4	30·5	26·9	28·3
Differences from check of mean yields of—												
3. Four strains which showed the highest yields in 1914 ..	17·5	3·6	9·7	7·5	4·9	8·2	—1·0	—·2	3·6	—·7	2·0	—·1
4. Five strains which showed the greatest yields on the average of 1919–22	20·1	4·1	4·4	6·4	4·3	7·9	1·1	·2	4·1	2·0	2·2	·5
5. Four strains which showed the lowest yields on the average of 1914–18	14·1	—2·3	1·6	—1·3	—1·6	·1	—8·5	—·9	—2·4	·3	1·5	1·1

Omitting 1910—$r_{13} = -·67$, $r_{14} = -·60$.

early year). The yields of these four strains appear to be in the later years approximately equal to the yield of the check. If instead of taking the strains which seemed best in 1914, we consider the five strains which seemed best on the average of the years 1919 to 1922, we obtain the figures shown in row 4 of Table 2, and a correlation of $r = -.60$ ($n^1 = 11$, $P = .05$). Since by selecting the strains with the highest values at the *end* of the time period, we are deliberately selecting our data in such a way that random errors may operate *against* the full expression of negative correlation with time, this correlation must be considered significant.

Row 5 of Table 2 shows the annual mean yields for the four strains which showed the lowest yields on the average of the years 1914 to 1918. They are approximately equal to the check throughout, showing significant differences only in 1910 (*vide ut supra*) and in 1917. These results are to be expected, since selection was for high yielding strains only, and not for divergent types.

Data from large field plots (Table 69 of bulletin) are similar in all respects.

From this evidence, it appears to be established that it was possible to select in 1907 out of the original Turkey Red variety, strains which differed appreciably in yield, but that by about 1921-1922 the yields of

all of these strains had become equal at the same level of yield as that shown by the original variety. One possible cause of reversion is that there may have been mixing of the strains with the original variety which was sown as a check in each year. Assuming perfect technique in the handling of all lines, such mixing could take place owing to natural crossing. However, other data in the same bulletin furnish circumstantial evidence against this explanation.

Similar single plant selections were made from the same variety in 1902, and continuous selection was made within the strains so established until 1906. In Table 13 of the bulletin, there are compared the yields during the crop years 1914-1922 of the best five strains originating from selections in 1902-1906, and of the five best strains originating from the single selection in 1907. Thus compared, the 1902 selections appear to be inferior to the 1907 selections. But in Table 3 herewith, we may compare the differences in yield between the five best strains and the check for each group with respect to the number of years since initial

TABLE 3.—COMPARISON OF STRAINS CONTINUOUSLY SELECTED 1902-06, WITH STRAINS SELECTED IN 1907 WITH RESPECT TO NUMBER OF YEARS FROM SELECTION.—DIFFERENCES FROM ORIGINAL VARIETY IN BUSHELS PER ACRE.

Years since Selection.	Mean 5–8	Mean 9–12	12	13	14	15	16	17	18	19	20
Five "best" strains selected in 1902	4·7	1·1	·6	3·5	*3·3	— ·6	·3	2·6	·3	·4	—1·3
Five "best" strains selected in 1907	6·7	4·2	3·3	·7	·9	·7	..	..	..	..	..
Five "poorest" strains selected in 1902 ..	—3·4	·3	·5	1·6	1·8	*—4·3	—·9	·2	—1·1	— ·5	—3·6
Five "poorest" strains selected in 1907 ..	— ·4	—2·9	—2·4	·3	1·5	01·1	..	..	..	..	..

* 1917. Average standard error = ·97.

selection. When regarded in this way, both lots of selections appear to have yielded similar results, and to have reverted to the yield level of the parent variety at about the same rate. It therefore seems that selection within strains was unable to check reversion. (The precise rigidity of selection between 1902 and 1906 is not clear from the published information, but it seems reasonable to assume that it would be adequate to at least maintain the yielding ability of the strains, if this were possible).

Speculation as to the cause of reversion is unlikely to be profitable until more accurate evidence of the changes is available. But, whatever the cause, there is no reason to suppose that technique at Nebraska was in any way inferior to standard practice in other plant breeding nurseries. The evidence therefore suggests that, although it may be possible to select improved high yielding strains out of existing wheat varieties, current breeding methods may be unable to establish commercial stocks which will maintain their initial superiority.

A review of the literature available has failed to discover evidence which may support or contradict the findings from the Nebraska data. McClelland* gives data for fourteen varieties grown in thirteen years, which indicate that differences between *varieties* do not tend to disappear when they are grown continuously in the same place. This is as we should expect.

It may be that some experiment stations have comparable data, which is either unpublished, or not available to the author, which could be used for further investigation of this matter. The importance of further investigation is self-evident.

* McClelland, C. K., Arkansas Agr. Exp. Sta., Bull. 278 (1932).

The Termite Population of a Mound Colony of *Eutermes exitiosus* Hill.

By F. G. Holdaway, M.Sc., Ph.D., F. J. Gay, B.Sc.,* and T. Greaves.**

Summary.

Termites of the species *Eutermes exitiosus*, an economic mound building species, congregate in the mound more in the winter months than at any other time. Studies of the population present in four mounds of similar size made during the winter yielded records ranging from just over 750,000 to over 1,750,000. The maximum record, 1,806,500, obtained just after the coldest snap of the period during which the studies were made, is probably the most accurate, and since the termites of a colony are never all present in the mound at the same time, it is probably a conservative estimate.

1. Introduction.

For certain of our investigations on *Eutermes exitiosus*, it is important to know, at least approximately, the population associated with a mound of the size we commonly use.† We have observed that a much larger proportion of the termites associated with a mound congregate within the mound during the cooler months than at other times of the year. The number of termites present in the mound during the winter is thus a closer approximation to the total population than is the number present at any other time. In the present article, an account is given of a study made during the past winter of the population present in each of four mounds.

In order to obtain the termites from a mound, it is brought into the laboratory, and broken up. A large number of the termites are then removed as living, undamaged individuals, free from dust, by a method which will be described in detail elsewhere. What proportion of the population was removed from each of the mounds referred to here has been estimated visually by each of us independently. Our estimates did not differ greatly, and, if they differed at all, they were averaged. It is probable that the proportion removed was 65 to 70 per cent. While it is possible to make only an estimate of the proportion removed, and the estimate is admittedly a rough one, the figures obtained serve to give an idea of the general order of magnitude of the population present in the mound.

The mounds discussed in the present paper have been used for the dual purpose of providing termites for experimental work, and for the estimation of the population present. The calculations have, as a result, been more involved than they would have been if the population could have been estimated alone. An example of the type of calculation which was necessary is given in the following section.

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* An officer of the Division of Economic Entomology, C.S.I.R.

† General information on this species and its mound will be found elsewhere, e.g., Hill 1932 A, 1932 B, Holdaway 1933.

2. Calculation of the Number of Termites Removed from Four Mounds and Estimation of the Populations Present.

The four mounds studied do not differ greatly in size. Particulars of them are given in Table 1.

Table 1.—Particulars of the Four Mounds whose Populations have been Studied.

Mound.	Date of Study.	Dimensions of Mound.	
		Horizontal Dimensions at Ground Level.	Height.
1	26th July	4′ 0″ x 4′ 3″	19″
2	8th August	3′ 4″ x 3′ 5″	19″
3	23rd August	3′ 7″ x 3′ 8″	16″
4	7th September	3′ 3″ x 3′ 10″	17″

For the experimental work, workers and soldiers only are required. After the termites have been removed from the material of which the mound is composed, some are taken for experimental purposes, and from these any nymphs or alates present are removed.

Example of the Type of Calculation Involved.

The following calculations, taken from Mound 2, are typical of the methods used to determine the number of termites present in the mound.

From ten 2 gm. samples without nymphs and ten 2 gm. samples with nymphs, the number of termites per gm. has been calculated to be as follows:—

Table 2.

Particulars of Termites.	Number per gm.
Workers and soldiers only	234·6
Workers, soldiers, and nymphs	225·2

The total weight of termites from which nymphs were removed was 1136.5 gms. Each gramme contained 234.6 termites. There were thus 266,500 termites, comprising only workers and soldiers.

From the other ten 2 gm. samples, which included nymphs, it was found that in every 450 termites, 11 were nymphs. So that in the 266,500 sorted termites, comprising workers and soldiers, 6,743 nymphs had been removed.

The total weight of unsorted termites comprising workers, soldiers, and nymphs was 4,000 gms. Each gramme contained 225.2 termites. There were thus 901,000 termites comprising workers, soldiers, and nymphs.

Thus the total number of termites handled was—

266,500	sorted termites.
6,743	nymphs removed.
901,000	unsorted termites.
Total .. 1,174,243	

It is estimated that 65 per cent. of the total population was removed. The population of this mound was thus approximately 1,806,500.

Certain other data of interest were obtained in the course of the estimation of this population.

(*a*) *Average Weight of the Castes Present in the Mound.*

The average weight of each of the main castes present in the mound was as follows:—

Worker	.00458 gm.
Soldier	.00183 gm.
Nymph	.01130 gm.

(*b*) *The Number of Each Caste Present in the Mound.*

From the average number of each caste present in 2 grammes of termites, it has been calculated, on the basis of the estimated population of 1,806, 500, that the different castes were present in the mound in the following numbers:—

Workers.	Soldiers.	Nymphs.
1,561,400	201,000	44,100

Thus approximately 44,000 alates would have emerged from the mound when swarming occurred.

(*c*) *The Weight of Termites in the Mound.*

The weight of termites handled was as follows:—

1,136.5	gms. (sorted).
87.7	gms. (6,743 nymphs removed).
.. 4,000	gms. (surplus unsorted).
Total .. 5,224.2	gms.

$= 11\frac{2}{5}$ lb.

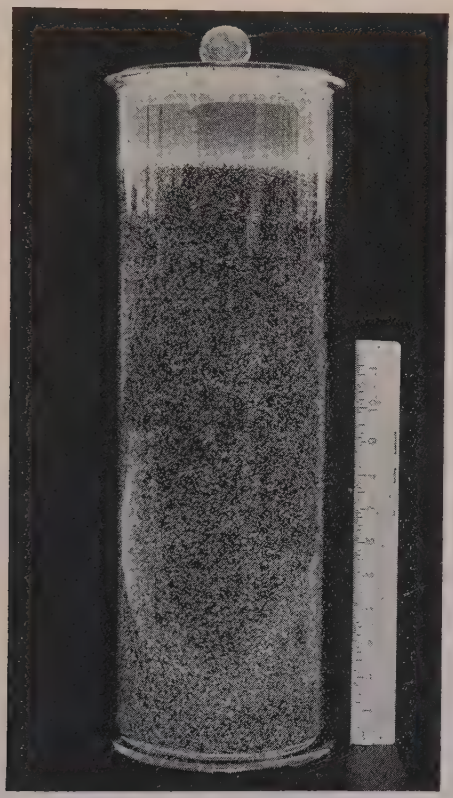
i.e., the total weight of termites present in the mound was 8.037 kilogrammes (approx.) $= 17\frac{1}{5}$ lb. (approx.).

Fig. 1 shows the bulk of approximately 1,000,000 termites of the species studied, or a little over half the number recorded for this mound.

A summary of the approximate populations present in the four mounds is given in Table 3.

TABLE 3.—SUMMARIZING THE APPROXIMATE POPULATION OF EACH OF THE FOUR MOUNDS STUDIED.

Mound.	Date.	Termites removed from the Mound.	Estimated percentage of the Termites present in the Mound removed.	Approximate Population present in the Mound.
			%	
1	26th July	522,817	70	747,000
2	8th August	1,174,243	65	1,806,500
3	23rd August	771,000	70	1,101,000
4	7th September	557,500	70	797,000



[*Photo W. James.*]

FIG. 1.—Approximately 1,000,000 individuals of *Eutermes exitiosus*.

3. Discussion.

One would expect that mounds of approximately equal size, with colonies in an active healthy state, and not at their maximum stage of growth, would contain approximately equal populations. The records for the populations present in the four mounds studied vary considerably, and the variation is not related to the slight differences in size

of the mounds. Our observations had suggested that, in a general way, temperature conditions played a part in determining the concentration of termites in the mounds. It is of interest now to consider whether the variation in population recorded bears a more particular relation to the temperature conditions at, and just prior to, the individual studies.

An examination of records of air and soil temperatures during the period when these studies were made shows that Mound 1 was studied following two cold snaps which had not been sufficiently intense to counteract the warming effects on the soil of a previous warm period. Mound 2 was studied just after the coldest snap of the period. After this, the mean trend of temperatures was upward. The populations recorded for Mound 3 and Mound 4 respectively were progressively smaller. Another mound of similar size studied on 21st November, when the weather was still warmer, showed a further decrease in the population present in the mound, the population recorded being only 484,300. It appears, therefore, that the records obtained were related to the temperatures reigning just prior to the day on which the particular studies were made, and that the population recorded for Mound 2 is greatest because the temperatures prior to the day on which this mound was examined were the lowest. If this is so, the record for Mound 2 is probably the most accurate estimation of the population associated with a mound of the size studied. Moreover, as one never finds all the termites associated with a mound present in the mound at the same time, it is in all probability a conservative estimate.

4. References.

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NOTES.

The Formation of the Australian Council of Agriculture—Re-organisation of the Standing Committee on Agriculture.

For some time past, it has been considered that were the Council's Standing Committee on Agriculture given an improved status beyond that possible to it as a Committee of the Council it would be able to carry out more valuable work on behalf of the Australian agricultural industry in general. The Committee itself was originally formed as the main result of a Conference the Council convened in March, 1927, to advise as to what place the Commonwealth could best fill in the field of agricultural research, and as to how co-operation in that field between the Commonwealth and the States could best be effected. The Conference recommended that in order to secure the necessary co-operation and collaboration, the Council should appoint a Standing Committee on Agriculture consisting of the permanent representatives of the State Departments of Agriculture, and of representatives of the Council, such Standing Committee to act as the advisory and consultative body on matters relative to agricultural and livestock research undertaken by the Commonwealth.

The Committee has recently been given an improved status in the following way:—

At a Conference of Commonwealth and State Ministers held at Canberra on the 3rd and 4th December, it was decided to form an Australian Council of Agriculture, in order that means might be provided for continuous consultation amongst Australian Governments on economic aspects of agriculture. The Council will consist of the Federal Minister of Commerce, the Minister in Charge of Development, and the State Ministers concerned. It will also have the power to co-opt the services of other Federal and State Ministers should necessity arise. The functions of the Council are as follows:—

(*a*) Generally to promote the welfare and development of agricultural industries.

(*b*) To arrange the mutual exchange of information regarding agricultural production and marketing.

(*c*) To co-operate for the purpose of ensuring the improvement of the quality of agricultural products, and the maintenance of high grade standards.

(*d*) To ensure, as far as possible, balance between production and available markets.

(*e*) To consider the requirements of agricultural industries, in regard to organized marketing.

(*f*) To promote the adoption of a uniform policy on external marketing problems, particularly those pertaining to the negotiation of intra-Empire and International Agreements.

(*g*) To consult in regard to proposals for the grant of financial assistance to agricultural industries.

(*h*) To consider matters submitted to the Council by the Standing Committee on Agriculture.

The Conference of Ministers also approved of the following recommendation of a Sub-committee it set up:—

"In order that the Council may adequately perform its functions it is essential, in the opinion of this Sub-committee, that there should be a permanent technical committee to be known as the Standing Committee on Agriculture, whose duties, in addition to advising the Council on the matters outlined above in clauses (*a*) to (*h*), should include the following:—

(i) To secure co-operation and co-ordination in agricultural research throughout the Commonwealth.

(ii) To advise the Commonwealth and State Governments, either direct or through the Council, on matters pertaining to the initiation and development of research on agricultural problems.

(iii) To secure co-operation between the Commonwealth and States and between the States themselves, with respect to quarantine measures relating to pests and diseases of plants and animals, and to advise the Commonwealth and State Governments with respect thereto.

In view of the proposed functions of the Standing Committee on Agriculture, as indicated above, it is considered that an appropriate personnel would be as follows:—

The Permanent Heads of the State Departments of Agriculture; members of the Executive Committee of the Council for Scientific and Industrial Research; the Secretary, Department of Commerce; and the Director-General of Health.

In order that the executive work may be in the hands of the persons most closely concerned, and recognising that the problems involved touch production, marketing and research, it is recommended that the secretarial work of the Standing Committee should be assumed by the Department of Commerce and the Council for Scientific and Industrial Research jointly.

If these recommendations be adopted, the present Standing Committee on Agriculture of the Council for Scientific and Industrial Research will be absorbed in the new body."

It is probable that the first meeting of the newly constituted Standing Committee will be held in about April, 1935, preceding by a day or so a meeting of the Australian Council of Agriculture.

Commonwealth Grant for New Laboratories for Council.

It has been obvious for some time past that certain branches of the Council's activities were being seriously hindered by lack of adequate laboratory accommodation. The Division of Forest Products, in particular, has, since its establishment, been working in makeshift laboratories set up in outbuildings at the head-quarters of the Council at East Melbourne. Naturally, the accommodation that is available to the Division at this location is very cramped.

The Commonwealth Government has been advised of the position from time to time. It has now decided to make funds available to the Council for the erection of central laboratories for the Division of Forest Products, and also for the erection of a laboratory at the Viticultural Research Station at Merbein. The grant will be made available from loan funds allocated for the relief of unemployment. £25,000 has been made available for the Division, and £6,000 for the Merbein Station.

Plans for the erection and equipment of the two buildings are now being prepared.

The Preservation of Citrus Fruit—Grant of £2,000 per annum for Five Years.

A programme of co-operative investigations on the problems connected with the storage and transport of citrus fruit was commenced in 1927, when a special Committee consisting of representatives of the Victorian Department of Agriculture, the Victorian Railways, the Victorian Central Citrus Association, and the Council for Scientific and Industrial Research was formed. The programme itself has been carried out on a basis of team work in which the organizations represented on the Committee, as well as others, have helped from time to time.

During the years since it was formed, the Committee has carried out a number of experiments dealing with various aspects of storage problems of both Navel and Valencia oranges. The efficiency of a number of washing solutions and of paraffin spray to control mould growth, the optimum temperature for storage, and the effects of different wrapping papers and of different methods of packing on storage life, have been tested over a number of seasons. Of late, the effect of maturity at time of picking has been the principal line of research.

For the most part, the experiments have been conducted in Melbourne with fruit from the principal Victorian citrus-producing areas, but, for the purpose of comparison, fruit has also been brought from the other States. During the last two years, experiments comparable with those being undertaken in Melbourne were carried out at the Citricultural Research Station, Griffith, by the officers of that Station in co-operation with the Station's Advisory Committee. During the last season, small experimental consignments of export oranges were sent to England, and, with the co-operation of the British Food Investigation Board, observations were made on the condition of the fruit on arrival.

Although a good deal has been accomplished since the establishment of the Citrus Preservation Committee, the scope of the work has, owing to lack of funds, had to be limited, both in regard to the scale on which the experiments were planned and the number of problems investigated.

During the years which have elapsed since the inauguration of this work, the importance, from the industry's point of view, of developing a successful export of high quality fruit, has become increasingly evident. For instance, the production of the industry is increasing year by year and is already greater than the demand of the local market. Representations were made to the Government by the Council and by the Commonwealth Citrus Investigation Committee to the effect that a

greatly increased grant for this work was urgently necessary. These representations have now resulted in a sum of £2,000 per annum for five years being made available to the Council for the work.

With the increased funds, and with a wider application of the principle of team work, it is hoped to extend the investigations to embrace fruit from all the principal citrus-growing areas. The problems which it is hoped will be investigated, in addition to those on which a certain amount of work has already been done, will probably include a consideration of the influence of orchard factors such as stock, strain, manuring and irrigation on the keeping qualities of the fruit, additional washing experiments, and the investigation of fungal rots other than the common moulds, as well as more extensive storage experiments at different maturities and different temperatures. As the different varieties of Seedling oranges are of appreciable importance to the export trade, it is also hoped to extend the investigations to include experiments designed to throw further light on the storage qualities of these varieties as well as of Navels and Valencias.

The Production of Oysters and Prawns in Australian Waters.

(Note by Professor William J. Dakin, D.Sc.)

In the November number of this *Journal,* some notes were inserted on a short talk which I gave to the New South Wales State Committee. The talk was particularly concerned with certain research carried out by myself and colleagues, and in the course of it I referred to our discovery of the interesting life history of the commercial prawns. I pointed out that the prawn industry, although a small one, was not negligible, and that in one year (1931) the product had, according to official figures, even exceeded the value of the oysters. The statement in the *Journal* is introduced by the words: "This is not so important an industry as some other branches of Australian fisheries, although it was worth to New South Wales in 1931, £21,000 more than the oyster industry."

Notwithstanding the qualification which I expressly made, and the citation of only one year, one reader of the article has taken this citation as a reflection on the importance of the oyster industry.

In order to prevent any one else who may have been interested in the article (which was really concerned with another side of the matter altogether) from making a similar mistake, I append the official figures given by the New South Wales Department of Fisheries for the two industries. I think the general public will probably be surprised that the prawn industry is as valuable as indicated, especially during the last three years when it has not lagged far behind the oyster industry.

There is of course no question about the greater value of the oyster industry, and I should think that fact is well known. Actually, the oyster industry is one of cultivation, and a great deal is understood about the matter. The prawns, on the other hand, are just captured wholesale in rather limited waters and, as I indicated in my talk, without the hunters having any definite knowledge of the conditions under which they breed, or where they breed.

Under such circumstances, a study of their habits is, to my mind, well worth while, especially if it is desirable to conserve an industry which is providing the means of livelihood for a number of fisherman.

Year.	Prawns.	Oysters.
1925	£32,119 ..	£92,774
1926	26,044 ..	103,597
1927	27,083 ..	98,484
1928	36,779 ..	94,834
1929	27,977 ..	103,887
1930	23,819 ..	63,680
1931	76,871 ..	55,166
1932	57,528 ..	69,108
1933	48,506 ..	56,954

(Prawns, valued at 6d. per lb. 1925-30; 1s., 1931; 9d., 1932-33.)

Tobacco Breeding Work of the New South Wales Department of Agriculture.

(We are indebted to Mr. H. Wenholz, Director of Plant Breeding, for the following interesting statement of the Department's Work.—Ed.)

Breeding work with tobacco has been conducted by the New South Wales Department, formerly with the chief idea of breeding for resistance to black root rot (*Thielavia basicola*). Although this disease has reached epidemic conditions during some years at the Bathurst Experimental Farm, where the breeding work with tobacco was being conducted, a survey of the main commercial areas where tobacco is now grown in New South Wales has shown that it is of little or no consequence, and this phase of tobacco work has now been abandoned.

In its place, the much more serious blue mould disease (*Peronospora hyoscyami*) is now being investigated from the breeding standpoint. It is by no means certain that it will be possible to make any improvement in commercial tobacco by the development of varieties which are more resistant to blue mould, but the disease is so serious that any slight hope in this direction is well worth pursuing.

The first step in this project has been the subjection of a large collection of local and introduced tobacco varieties to artificial infection tests with blue mould to determine their relative resistance or susceptibility to the disease. This work has been carried out by plant breeders at the Glen Innes Experiment Farm, and has consisted of artificial infections of seedlings in several sowings. It has been found that young seedlings are generally susceptible to attack, but that the relative reactions of varieties of blue mould are best indicated when the inoculations are made on seedlings in a somewhat advanced stage of growth.

No variety of *N. tabacum* was found to possess any high resistance to blue mould, but some varieties appeared to show some tolerance to it, while others were extremely highly susceptible. The light leaf Virginia types being grown commercially at present in Australia, viz., Cash, Warne, Yellow Orinoco, White Stem Orinoco, Goldleaf, &c., are in the latter category. Some hybrid tobaccos from India, and some introductions from Paraguay, appear to have most tolerance to the disease, and an attempt is being made to grow on in the glasshouse some seedlings of these varieties which have survived seedling infection.

It was generally believed that the tobacco types of the species *N. rustica,* were resistant to blue mould. A collection of varieties of this species introduced from various parts of the world was tested at Glen Innes, and while some varieties were found to be highly resistant, the species group varies considerably in this respect, some varieties being quite susceptible.

The native or wild tobacco (*N. suaveolens*) has consistently shown immunity from blue mould in artificial seedling infection at Glen Innes.

This is only one season's work, and needs confirmation or corroboration from further tests.

The possibility of using *N. suaveolens* or the resistant types of *N. rustica* as parents with cultivated varieties of *N. tabacum* to produce a commercial variety of tobacco resistant to blue mould, has not been explored in any part of the world. Great difficulty is likely to be encountered in making such crosses successfully, and the subsequent selection and fixation of a suitable commercial type of tobacco from such wide crosses is also likely to be attended with extreme difficulty. Nevertheless, such crossing is being attempted by the New South Wales Department. A grower at Kyogle has stated that he has succeeded in crossing the wild tobacco with a cultivated variety, and seed has been obtained from him.

Crossing incompatibility between *N. tabacum* and *N. rustica* has already been the experience in other parts of the world, but a few cases are on record where success has been achieved with this species cross, though no breeding material from such a cross is being carried on with the practical objective of producing a commercial variety from the cross.

In species crossing, it is often found that varieties play a big part in the success of the cross, probably on account of some affinity or similarity of the chromosomes. A very large number of crosses between different varieties of these two species was therefore attempted last season at the Glen Innes Experiment Farm, and some good plump seed has been obtained from at least some of these crosses, while other crosses failed entirely.

A further possibly serious drawback to the use of the *rustica* parent in breeding is the severe damage done to all varieties of this group by the tobacco leaf miner, but this susceptibility may be helpful in the selection of *N. tabacum* types from such a cross.

In addition to the above crossbreeding programme, crosses have also been made between the varieties of *N. tabacum* which appear to be most tolerant to blue mould. It is just possible that a higher resistance to the disease may be obtained from these crosses through the action of complementary factors in inheritance.

Sheep Licks—The Effect of Fluorine Compounds.

Following the comparatively recent use of ground rock phosphate in licks intended for sheep, statements have been made that the fluorine compounds, which are frequently present in appreciable amounts in such rock phosphate, are harmful to the animal. The Council's Division of Animal Nutrition has recently given some attention to this point,

and the following extract from the Annual Report of the Council will be of interest in connexion with it:—

> "Experiments with pen-fed sheep indicate that the ingestion of 500 mg. of fluorine per day as Florida rock phosphate plus calcium fluoride is well tolerated by mature animals for several months. After the lapse of about 9 months, acute anorexia develops and this is accompanied by a rapid decline in weight which culminates in death. The skeletons of such animals are characterized by chalky exostoses on the bones, these outgrowths being most prevalent on the maxillae. Young pen-fed sheep receiving 115 to 150 mg. of fluorine per day have maintained their growth rate for a year, but are now showing some untoward symptoms. The permanent teeth of these animals are erupted with mottled enamel. Those animals which constitute the group receiving 80 mg. of fluorine per day for over a year have not suffered in any way; they have continued to consume as much fodder and have grown as well as their normal controls. It may reasonably be concluded that the continual ingestion of from 2 to 3 mg. of fluorine per kilo body-weight is well tolerated by the sheep, and that the ingestion of up to 80 mg. of fluorine per day in the form of rock phosphate will not be followed by any symptom of chronic fluorine poisoning."

The fluorine content of different deposits of rock phosphate varies considerably, being, in general, much lower in island deposits such as those of Curacoa and Christmas Island, and to a lesser extent Nauru, than in continental deposits such as those of North Africa, which often contain up to 3 per cent. of flourine.

Crop Size and Wastage in Apples.*

(Contributed by W. M. Carne and D. Martin, B.Sc., of the Division of Plant Industry.)

Cox's Orange Pippin exported from Australia is mainly grown in Tasmania. It is regarded in Great Britain as the most valuable dessert apple, when in good condition, but it is in little demand in Australia. Unfortunately, it is more subject to deterioration, particularly to storage pit and breakdown, than any other important variety exported. Six seasons of investigation in southern Tasmania have shown that the wastage in the fruit from grown trees varies with the soil and other site factors, the seasonal climate, the maturity of the fruit when picked, the size of the crop from which it came, the storage temperature, and the length of distribution period after removal from cool storage. Of these, the most important have been the seasonal climate, the maturity of the fruit when picked, and the size of the crop.

The performance of the fruit of an individual tree in a group under the same conditions, compared with that from the other trees in the group, depends upon the relative size of the crop on each tree. Picking must therefore be based primarily on the crop of each tree. Light crop trees are found to give fruit of poor keeping quality. Light crop trees in one season are normally heavy crop trees in the next, and vice versa.

* A summary of a report dealing with investigations in Tasmania on the wastage of non-parasitic origin developed in apples stored locally or shipped overseas, with special reference to Cox's Orange Pippin.

A light crop is one in which the fruit averages more than normal size. The normal size for Cox's Orange Pippin is 2¼ inches at mid-season, while light crops average 2⅛ inches or more in the first week of February.

Fruit from light crops is larger and ripens earlier than that from heavier crops, but loses its starch and pit-liability later. It is usually the first to be picked and shipped overseas, and is largely responsible for the frequent complaints of pit in the earlier shipments of each season.

In heavy crops, there is a period for picking which will give reasonably good results if the fruit is shipped shortly after picking. In light crops, there is no such period, because the early liability to bitter pit overlaps the later liability to breakdown.

For good flavour and appearance, the fruit should be picked when the ground colour is first distinctly yellow-green. Picking should not be delayed until the colour is green-yellow, as the fruit will then be liable to breakdown and over-ripeness. Ground colour is not a completely effective guide to pit-liability, especially in light crops, but when the iodine test shows the core free from starch and definite evidence of starch loss in the rest of the apple, pitting will be practically negligible.

Pit-liability has been associated with seasons which are above normal for temperature in January and February, and it is greatest in immature fruit. Pit breakdown accompanies pit in fairly mature apples. Low temperature breakdown has been associated with summers of subnormal temperatures, and it increases with the maturity of the fruit when picked. Hot summers have been followed by late ripening in the fruit and the reverse in cool summers. Hence, at the same calendar date, fruit is more mature in one season than another. The differences in the amount and type of wastage in different seasons are in part due to the practice of commencing picking about the same date each season.

Less pit developed at 60 degrees than at cool storage temperatures, and at that temperature became apparent on most apples likely to be affected in 10 to 18 days. If picked when yellow-green, Cox's Orange Pippin will keep 30 to 40 days at 60 degrees without shrivelling.

Breakdown has been reduced by the storage of fruit at 39 degrees as compared with 34 degrees, and in 1933 when low temperature breakdown was prevalent the reduction was of the order of 50 per cent.

The following recommendations are made for the picking of Cox's Orange Pippin for export:—

Mark all light crops early in February. Pick when the ground colour is definitely yellow-green and keep apart from the fruit from good crops. Regard any doubtful trees as light. Hold the fruit naked in packing boxes in the packing shed for 15 days in warm seasons to 18 days in cool in southern Tasmania, or less in warmer districts. Then pack the surviving sound fruit and ship or cool-store promptly.

Pick good to heavy crops when yellow-green. When in doubt as to pit-liability, and especially after warm summers, test representative fruit with iodine. Do not pack unless the test shows that the core is free from starch and there are definite signs of starch loss in the other tissues.

The fruit should not be allowed to become equally yellow and green or green-yellow on the trees, especially after cool summers.

Fruit should not be precooled unless it comes from heavy crops and is not in a pit-liable condition as shown by the iodine test or unless it has been held in a shed to pit before packing and immediate shipping space is not available.

Cox's Orange Pippin is so generally pit-liable in Tasmania that it should always be regarded as such unless there is abundant evidence that some of the trees in certain orchards are so free from this trouble that it may be neglected in those cases.

Mining Investigations—(*a*) Mineragraphic Research, and (*b*) Ore-Dressing Research.

In 1934, the Government decided to make the Council a grant of £5,000 per annum for a period of 5 years in order that research work that would be of value to the mining industry, and particularly to the gold-mining industry of Australia, might be undertaken. It has been frequently pointed out of late in Australia that were the methods of the gold-mining industry, in particular, improved, more deposits could be profitably exploited, and there would be no difficulty in getting rid of the increased production in view of the present world-wide demand for gold.

In planning investigations that could be undertaken with the £5,000 per annum available, the Council has been fortunate in obtaining the advice of many prominent mining authorities in Australia.

It has been decided for the time being to intensify the mineragraphic investigations on which Dr. Stillwell was formerly the sole investigator engaged, and also to carry out a programme of ore-dressing research. The mineragraphic work consists of the application of a special technique whereby ores and metallurgical products may be examined under high magnifications and the precise minerals present, their average size, and their associations with other minerals, determined. This information is of considerable value to the mining geologist in that it provides him with information concerning the mode of formation of the deposit, and thus serves as a guide to its future prospecting and development. The information is of even more value to the metallurgist in that it tells him precisely what minerals he has to separate by the various machines such as jigs, flotation cells, &c., at his command. As a result of the decision to intensify work of this nature, Dr. A. B. Edwards has recently been appointed as an assistant to Dr. Stillwell.

Another decision that has been made is to allocate for the time being £3,000 per annum in order that certain ore dressing investigations might be carried out at the Kalgoorlie School of Mines, the Adelaide School of Mines and Industries, and the Metallurgy School of the University of Melbourne, the authorities of these organizations having very kindly offered their co-operation. Research officers have already

been appointed to Melbourne and Adelaide (Mr. S. S. Pullar and Mr. A. B. Beck, respectively), and arrangements for the location of a similar officer at Kalgoorlie are in train. In the meantime, extra equipment for the laboratories is being obtained.

The ore-dressing work itself is being greatly helped by a Mining Advisory Committee consisting of three leaders of the mining industry —Messrs. G. C. Klug, H. St. J. Somerset. and W. E. Wainwright— with Sir David Rivett as Chairman. In addition, local sub-committees have been set up in connexion with the three laboratories, and here, too, mining authorities have been most helpful in affording their assistance. The sub-committees are each representative of the laboratory, the local State Department of Mines, the Australasian Institute of Mining and Metallurgy, and the local Chamber of Mines.

As at present constituted the personnel of these Sub-committees is as follows:—

Melbourne.—Professor J. N. Greenwood (*Chairman*), W. Baragwanath, Esq., H. Hey, Esq., and W. J. Rose, Esq.

Adelaide.—Dr. L. Keith Ward (*Chairman*), F. W. Reid, Esq., Professor Kerr Grant, and H. W. Gartrell, Esq.

Kalgoorlie.—R. C. Wilson, Esq. (*Chairman*), F. G. Brinsden, Esq., C. E. Blackett, Esq., and Dr. B. H. Moore.

Review.

"The Life Forms of Plants and Statistical Plant Geography," being the collected papers of C. Raunkaier. Oxford: at the Clarendon Press, 1934, pp. i-xvi and 1-632 with 189 photographs and figures. 35s. net.

It has sometimes been stated that botany is merely a descriptive science, meaning that its results are not presented with the precision of a physical science—that they do not admit of mathematical treatment. The late Professor C. Raunkaier did much to remove that reproach, if it be one, by extending the use of statistics to a branch of botany in which they had not previously been applied.

The comparison of the vegetation of different regions of the earth is a difficult matter, but it is a concern of both the botanist and geographer. Mere lists of species convey little, while any attempt to describe a flora in terms of a few selected species is open to grave objection. It by no means follows that the most obvious species are the most important in the composition of the vegetation, or that they throw any real light upon its relations to that of another area.

In his system of life forms and in their statistical treatment, Raunkaier devised a method of stating results clearly, concisely, and free from the disadvantages inherent in any subjective presentation. Other workers before Raunkaier had grouped plants according to their life forms, but the systems lacked a uniform basis of classification. Raunkaier adopted the single criterion of the degree of protection afforded to the vegetative or renewal buds during the adverse season (heat of summer or cold of winter). There are five main groups—the phanaerophyte, whose buds are freely exposed well above the ground; the chamaophyte, whose buds are above the ground but close to it (within 25 cms.); the hemicryptophyte, whose buds lie in the crust of

the soil; the cryptophyte, whose buds are well below the surface; and, lastly, the therophyte, the annual plant, which persists from season to season as seed. These five main divisions have been further divided chiefly by recognizing different classes of phanaerophytes (very tall trees, trees up to 30 metres, scrub, and shrubs) and cryptophytes.

To compare two plant climates, the floras of the two regions are separated into classes, and the results presented as a series of percentages of each class in its total flora. This gives a biological spectrum. A standard of comparison is given by the world spectrum, which Raunkaier obtained by an ingenious method of sampling the whole flora, using the Index Kewensis as a basis.

The use of life form statistics is becoming generally known through ecological work. They were first employed in Australia by Adamson and the present writer, and have later been used to good effect by Wood in his studies of the Mallee and of Kangaroo Island in relation to the adjacent mainland.

But Raunkaier extended the use of statistics to other aspects of vegetation, notably in his study of leaf size and in the comparative analysis of florulas of local communities, termed by him "formations." This latter work is of a type that has lately come into prominence in pasture analysis, though the purpose of a botanical study may differ from an agricultural. The botanist, as Raunkaier recognized, is more concerned with the specific frequency or with the area occupied by a species than he is with the composition of the yield, which only gives a picture of the vegetation at the time of harvesting.

Most of Raunkaier's work was published in Danish and in journals not always easily accessible in English-speaking countries. It has been made known in them largely by the two valuable summaries, that of Smith (*J. Ecol.*, i, 1913) and Fuller and Bakke (*Plant World*, xxxi, 1918). Neither could do more than indicate the method and type of result. His later work, particularly an important paper (1928) on the analysis of "formations" (communities), was only available in Danish.

The Oxford University Press has done a great service to all students of vegetation and plant geography by the publication of an English translation of Raunkaier's work. In this, there is available within the covers of one book an authoritative collection of his works. The whole makes a handsome volume of over 600 pages with 189 figures, part line diagrams and part excellently reproduced photographs of vegetation in Denmark, the Danish West Indies, and the Mediterranean littoral. The work of translation has been done by Mr. H. Gilbert-Carter of the Botanic Gardens, Cambridge, and Professor A. G. Tansley of Oxford.

The various papers and books included in the volume are arranged in chronological order as chapters of very unequal length. In this way, it is possible to follow the development of Raunkaier's ideas from their first presentation to the Danish Botanical Society in 1903 through their various modifications and elaborations to their final form. The last chapter (1928), on "the area of dominance, species, density, and formation dominants," together with an earlier chapter, "Statistical researches on plant formations" (1928), are specially valuable to all interested in the analysis of vegetation whether in pastures or in its natural state.

"Numbers are the metrical units of Science. Verses may halt and so also may the numbers of science," to quote from the conclusion of one of Raunkaier's important papers. All students of vegetation, whether in its natural state or as it is "improved" and modified by agriculture, owe a debt to Raunkaier as a pioneer in the statistical study of plants. T.G.B.O.

Recent Publications of the Council.

Since the last issue of this Journal, the following publications of the Council have been issued: —

Bulletin No. 84.—"The Basal (Standard) Metabolism of the Australian Merino Sheep—II.," by A. W. Peirce, B.Sc.

The Bulletin consists of a second report that the Division of Animal Nutrition has prepared in connexion with the metabolism of the Australian Merino sheep, the first report having been published as the Council's Bulletin No. 55. In the present report, the influence of age, sex, nutritive level, and shearing, as well as bodily position during the determination, have been studied. Seasonal variations in the pasture causing wide differences in its nutritive value brought about large changes in the standard metabolism at various periods of the year. The average value for five sheep showed a maximum of 1,350 Cals./m^2/24 hours in winter or spring, the much lower value of 1,080 early in summer, with a minimum of 1,040 in the autumn, when the nutritive value of the pasture was also at a minimum. The heat production of nine sheep while standing quietly was found to be 8 per cent. above the value in the lying position. With information on basal metabolism, the minimum amount of energy-producing food required to keep the animal alive during periods of drought when the natural pasture is exhausted can be derived, and with the data available as to the energy contained in different foodstuffs, their digestibility, and their price, the cost of the most economical hand-feeding can be calculated.

Bulletin No. 85.—"Studies on the Phosphorus Requirements of Sheep. II.—The Effect of Supplying Phosphatic Supplements to Growing Lambs Depastured on Phosphorus-Deficient Country," by H. R. Marston, E. W. Lines, B.Sc., T. J. Marshall, B.Agr.Sc., and J. S. Hocking, M.Sc.

The Bulletin gives the results of experiments carried out on sheep depastured on a phosphorus-deficient area in South Australia, but one which nevertheless has a satisfactory rainfall. Seven groups, each of 25 ewe lambs of similar age, were rotationally grazed through seven divisions of an area on which the soils were deficient in plant foods generally, and contained 0.012 per cent. of phosphorus. One of these groups, which acted as a control, was allowed free access to a lick composed of salt and molasses; the other six were offered *ad lib.* licks composed of phosphatic supplements mixed with salt and molasses. The consumption of these licks was small, the one with bone meal as a constituent being taken more readily than those compounded from ground Nauru rock, dicalcic phosphate, neutralized superphosphate, or calcium glycerophosphate. The general conditions which lead to nutritional maladies associated with phosphorus and protein deficiency in grazing sheep are discussed.

Pamphlet No. 50.—"The Design of Overhead Irrigation Systems," by E. S. West, B.Sc., M.S., and A. Howard, M.Sc.

The work in this Pamphlet forms a part of the programme of investigations of the Commonwealth Research Station, Griffith, in which the Water Conservation and Irrigation Commission of New South Wales is co-operating with the Council. The publication discusses the advantages and disadvantages of spray or overhead irrigation as compared with surface methods, pointing out that the chief advantage of overhead watering lies in the greater control which can be exercised over the quantity and distribution of the water applied. On the other hand, the disadvantages of the overhead spray method are its initial cost, the cost of pumping the water, and the depreciation of plant. A system of spray irrigation in use in the Murrumbidgee Irrigation Areas is described in detail, and investigations into the hydraulics of the system are reported and the results discussed. Formulae which show the relationships between the pressures of water used, discharge from the laterals, and fall in pressure along the laterals, when the constants depending on the frictional loss of laterals and discharges from orifices are known, are elaborated. The costs and methods of installation and design are indicated.

Pamphlet No. 51.—"The Chemistry of Australian Timbers, Part I. —A Study of the Lignin Determination. II. (Division of Forest Products—Technical Paper No. 14)," by W. E. Cohen, B.Sc.

The determination of lignin in wood has presented great difficulties, and wood chemists have for a long period devoted much time to the solution of the problem. One of the reasons for the Division's interest in this question was that it was hoped to use the lignin-cellulose ratio as a diagnostic factor in identification. The expected results were not obtained, possibly because of the often serious errors in determining the lignin. The Pamphlet sets out the results of recent work towards the development of a satisfactory procedure for the determination of this important wood constituent.

Forthcoming Publications of the Council.

At the present time, the following future publications of the Council are in the press:—

Bulletin No. 86.—"A Soil Survey of the Berri, Cobdogla, Kingston, and Moorook Irrigation Areas, and of the Lyrup Village Settlement, South Australia," by T. J. Marshall, M.Agr.Sc., and P. D. Hooper.

Bulletin No. .—"Radio Research Board Report No. 6. 1. On the Plane of Polarization of Long Radio Waves. 2. A Field Intensity Set. 3. Measurements of Attenuation, Fading, and Interference in South-Eastern Australia at 200 kilocycles per second."

Bulletin No. .—"Radio Research Report No. 7. The Propagation of Medium Radio Waves in the Ionsphere. 2. The Characteristics of Downcoming Radio Waves. 3. The Influence of Electric Waves in the Ionosphere. 4. Long Distance Observations of Radio Waves of Medium Frequencies."

Bulletin No. .—"Radio Research Board Report, No. 8. 1. Simultaneous Observations of Atmospherics with Cathode-Ray Direction Finders at Toowoomba and Canberra, by G. H. Munro and H. C. Webster. 2. Atmospheric Interferences to Reception, by W. J. Wark."

Bulletin No. .—"The Identification of the Principal Commercial Australian Timbers other than Eucalypts," by H. E. Dadswell, M.Sc., and Audrey M. Eckersley, M.Sc.

Pamphlet No. 52.—"Systematic Entomological Contributions. 1. Notes on the Genus Hexamera B. & B. Dipt. Tachin, by A. L. Tonnoir. 2. Australian Hamitermes (Isoptera), with Descriptions of New Species and Hitherto Undescribed Castes," by G. F. Hill.

Pamphlet No. .—"Thrips Investigation: Some Common Thysanoptera in Australia," by H. Vevers Steele, B.Agr.Sc., M.Sc.

Pamphlet No. .—"The Selection, Preservation, Distribution, and Identification of Australian Pole Timbers," by J. E. Cummins, M.Sc., and H. E. Dadswell, M.Sc.

Pamphlet No. .—"The Identification of Wood by Chemical Means, Part II.—Alkalinity of Ash and Some Simple Chemical Tests for the Identification of the Coloured Woods of the Genus Eucalyptus," by W. E. Cohen, B.Sc.

Pamphlet No. .—"The Occurrence of Bovine Babesiellosis in Northern Australia," by J. Legg, D.V.Sc.

Pamphlet No. .—"The Carriage of Bananas," by E. W. Hicks and N. E. Holmes.

H. J. Green,
Govt. Printer, Melbourne.